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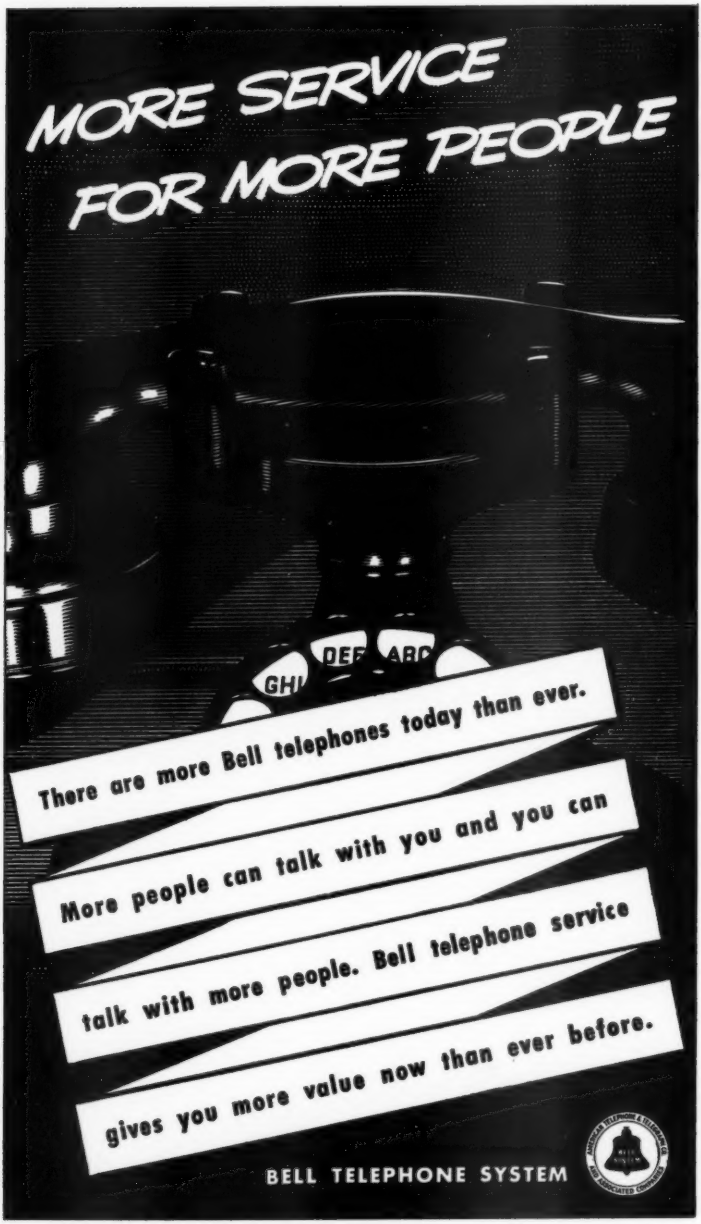
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THE CULTURAL AND PROFESSIONAL PHASES OF ENGINEERING EDUCATION

S. B. EARLE, *President of the Society*

For the past few years it has been customary to have some theme for the annual meeting of the S. P. E. E. Two years ago emphasis was placed on "Character Development." Last year "The Teacher" was stressed. This year we have chosen "The Cultural and Professional Phases of Engineering Education." The early engineer's work was largely with materials, but with the advances that have been made it has become more and more necessary that the engineer deal with men. Because of the developments which have been so rapid in the engineering field, there has been a tremendous demand for the technically trained man. Because of this demand and because the engineer's work was so largely along design the technical phase of his education was naturally given special stress. The great advances, however, in the engineering fields have brought along with them many changes in our social and economic conditions. Such developments as rapid transportation, the radio, etc., have changed our social order so rapidly that considerable study must be given to this phase as well as to our economic problems. The engineer today is required to have not only a good technical training but at the same time more attention must be given to his cultural development. It is realized that there is hardly sufficient time in the four years in college to give the necessary training in all of these lines but it is hoped that at least interest may be stimulated. The E. C. P. D. recognizes this and is attempting to bring to the institutions better trained material with the hope that the colleges during the four years will continue the cultural training as well as the technical. While it is realized that only elementary training in these lines can be given it is hoped that interest may be stimulated and that after graduation the graduate will continue his development in order that he may become a real member of the engineering profession under present-day conditions.

It is hoped that interest in the general topic may be aroused at the meetings.

DEVELOPMENT OF THE YOUNGER TEACHER*

By W. K. LEWIS,

Massachusetts Institute of Technology

The first difficulty in securing the right type of the young teacher of engineering is psychological. The student comes to the engineering school because it appeals to him as a preparation for practical work in which his interest lies, and at graduation he is unwilling to sacrifie that interest and enter teaching as a profession. The second difficulty is economic, the fact that the school cannot compete with the salary scale of industry. The relative importance of the two factors changes with time after graduation. As the years go on, the young graduate often begins to appreciate the limitations of industry and the attractiveness of educational work. Granting, however, that he possesses the ability and personality essential for outstanding success in teaching, those qualities will soon carry him to a level of earnings in industry, which, whatever his attitude, will make it difficult for him to readjust himself to the lower standard of income which he must accept if he transfers to academic work. Experience indicates that the best policy is to attempt to hold the young graduate continuously in educational work, rather than to hope to attract older, practicing engineers into the teaching profession.

The third group of problems are pedagogic. Of these the most important are training in teaching technique and the development of an adequate background of professional experience. The former is rendered difficult not only by the absence of pedagogy as a formal subject of instruction in the engineering curriculum, but even more by what may be described as the absence of the pedagogic psychology in the point of view of the engineer. The solution of the second of these problems requires a sustained professional experience, suitable provision for which must be made in any successful program of engineering teaching.

It is the conviction of the writer that the practical solution of all these complex problems can best be found through an indirect approach, namely, through recognition and exploitation of the training value of teaching and instructional work to the practicing, professional engineer. The young engineering graduate of ade-

* Presented at the 45th Annual Meeting, S. P. E. E., Cambridge, Mass., June 28–July 2, 1937.

quate ability who is going into industry can profit greatly from experience in engineering teaching. Under that experience he can develop rapidly in thoroughness of grasp of the fundamentals of his profession, in the power effectively to utilize his training in the attack on practical problems, in the ability persuasively to present his point of view, not only to fellow technical men, but to men of other interests and outlooks, and thereby he can greatly increase his potential value to industry. These facts can be used as bait to lure some of the ablest young graduates into a period of teaching. However, if such a program is to succeed ultimately, it must be designated and operated to achieve its potentialities.

From a practical point of view, the program involves a small, permanent teaching staff of the highest caliber, supplemented by a larger staff of young graduates of outstanding ability and initiative. The turnover in this latter group will be very great, the average time of service being perhaps of the order of magnitude of a couple of years, most of the younger men serving but one or two years, very few of them as much as five or more. From among them, however, a small percentage can be brought to find the attractiveness and creative potentialities of teaching as a life work, and can thus be held permanently in the profession.

The instruction in which the young staff member is engaged should be professional, but not necessarily advanced in character. Indeed, the elementary courses in engineering offer a most valuable teaching experience.* The teaching of such topics as thermodynamics and mechanics and the elements of mechanical, electrical, mining, and chemical engineering will develop a thoroughness of grasp of professional fundamentals which can never be attained by the mere student. Furthermore, the experience can help the instructor develop a clarity and force in thought and expression difficult to achieve in other ways.

The instruction must not be allowed to become routine in character. Thus, one must never consent to the assignment unchanged of last year's problems. This is essential, not only to protect the student against reliance upon the fraternity house files, but equally to protect the instruction and the instructor against the deadening effect of mere repetition. The formulation of a good, new problem is a far more valuable intellectual experience than the solution of it. One of the tragedies of teaching is the difficulty of giving this experience to the student so long as he remains on the wrong side of the lecture desk. Moreover, this experience in problem formulation reacts to an extraordinary degree to vitalize instruction. The man who has made up a good problem has a grasp of its educational

* For professional training in engineering this is not true, or at least is true to a lesser degree, of work in the elementary subjects in pure science.

potentialities which it is almost impossible to get in any other way. So important is it to avoid the routine in teaching that it is desirable continuously to modify from year to year the content of the instruction in a given subject, although it is obvious that this practice must be kept within limits.

The instructional work should be so organized that the young teacher is never left entirely to his own responsibility, but works always under the leadership and direction of a senior member of the staff. While this contact should be intimate, it does not require that a high percentage of the work be done by the older man. Indeed, this is undesirable, because the organization should be designed to make possible and encourage initiative on the part of the beginner. To no small extent the work of the permanent staff member becomes that of training the younger teacher. As a matter of practical organization, our experience indicates that best results are achieved by having lectures handled by a member of the permanent staff, and recitations, preferably conducted in small sections, by younger instructors with some experience. It is very desirable to have at least one recitation section conducted by the man in charge of the subject, with young instructors and assistants attending this section to get point of view and method of approach. Inexperienced staff beginners serve as assistants, correcting problems, collecting material and, where practicable, conducting conferences with individual students to clear up difficulties.

While such a program can be conducted successfully with a surprisingly small permanent staff, it does demand that the staff be of high caliber, since otherwise it can never furnish the quality of inspiration and leadership to make the scheme a success.

The young instructor remaining with the department for some years should never be required to teach the same subject year after year, but should be shifted from one subject to another. The added training value to him is obvious. The argument is often advanced that a serious loss in instructional efficiency results. This need not be the case. The program here outlined makes it possible to attract young men of such high caliber that their technical and personal qualifications will far more than compensate for limited experience in the specific subject. Experienced mediocrity can never successfully compete with the combination of ability and enthusiasm properly directed.

To develop the younger staff in breadth and initiative, each member should be engaged in one way or another in a specific research project. This may be a work on a problem of his own, but preferably includes supervision of the thesis work of undergraduates or of junior graduate students. However, it should be emphasized that teaching by graduate research students primarily as a

method of financing their Doctor's degrees is not recommended. Such teaching is sure to be perfunctory and uninspired. While there is no objection to allowing the young instructor to get his Doctor's degree as a by-product of his instructional work, he should be made to realize that his teaching comes first, and should be attracted to the work by the conviction that to him the teaching experience itself is the most valuable thing about it.

Finally, to make the program successful it is necessary to educate the employer to an appreciaiton of its value. He must be brought to see that men of this additional age and experience do in fact possess an added capacity for achieyement that justifies him in paying them more at the start of their industrial employment and enables them to advance far more rapidly in industrial work. This task of salesmanship may be a slow one, but there is no reason to question its success if the men thus trained are properly chosen as to aptitude and are in fact given through their teaching the opportunities and incentives to personal development here described. On the other hand, the attempt to convince the employer of the advantages of such a scheme is doomed to ultimate failure unless the program does indeed confer the advantages claimed. Keeping this fact constantly in mind is a valuable guide in the administration of such a policy.

Looking to the relatively distant future, the engineering profession can do a great deal toward the improvement of the teaching of engineering by the development, both within the profession and outside it, of an adequate appreciation of the importance and scope of engineering in contemporary civilization. Culture may be defined as the measure of the breadth and depth of one's contact with life. In view of the extent to which modern life is dominated and conditioned by engineering, no member of this generation unfamiliar with its bases and methods can properly lay claim to breadth of culture. Furthermore, in a thousand and one human activities unrelated to engineering in the narrow sense, understanding of the engineering method and the capacity to use it can greatly enhance the power of the individual for effective action. As this situation becomes more clearly appreciated, the undergraduate school of engineering is sure to compete more actively with the arts college and to attract students from it,—though it is to be hoped that this will not result in flooding the engineering school with men temperamentally incapable of appreciating and profiting from engineering training and experience. However, in this relatively large group of men who in the future will take engineering courses for cultural rather than professional motives will probably be found a small percentage of students intellectually and temperamentally adapted to the work of engineering education. On the other hand,

despite the future possibilities, there exists to-day no such group upon which to draw.

The program just sketched makes no provision for the development in the teacher of an adequate background of professional experience. One of the great engineers of the country has defined engineering as the art of the economic application of science to social purposes. To be effective, the teacher of an art must practice it and practice it continuously. This fact constitutes one of the difficult problems of engineering education. For the permanent staff member, its best solution is found in the right sort and amount of consulting work, but this solution is not available to the beginner. On the other hand, the school can help the student to secure the right sort of experience. In the earlier years this is best done in the form of summer jobs of the right type, to furnish which the coöperation of industry should be sought. At a later point, it is often possible to give valuable experience to the younger staff as assistants in the consulting work of superiors. Finally, it is not difficult in the case of adequately able men of even moderate experience to find for them consulting work of their own.

This policy, involving a small permanent staff with a relatively large group of young instructors and assistants of short academic life, makes possible a desirable readjustment of the salary budget. Because of its limited size, the permanent staff can be paid higher salaries,—of course, not competitive with those of industry, but none the less more adequate than those often available to-day. The lower salary level of the younger men is compensated by the economic value of the training they are receiving, making it possible to get outstanding graduates for far less than industry is willing to offer.

If the plan is to succeed, administration must be fully prepared when ability and promise are discovered to give immediate and adequate recognition in responsibility, salary, rank and opportunity. Furthermore, one must be willing to reward pedagogic as well as research ability. However, if in your institution seniority is the major factor in promotion, waste no effort in introducing such a scheme as this until there is at least some hope of reducing seniority to its proper perspective. On the other hand, once in operation, by offering a relatively large group of thoroughly tested men from which only a few permanent staff members are to be chosen, the plan tends to eliminate seniority as a major administrative problem in promotion by reducing the chances of those errors in judgment which result in the misfits.

The plan can readily be used to promote the desirable interchange of staff between engineering schools, to reduce insularity and inbreeding. I was interested to find that of the total staff

membership of thirty seven of the department with which I am connected, twenty-nine, or seventy-eight per cent, hold their undergraduate degrees from other schools. It is highly desirable for schools to exchange recommendations, thus placing one's own graduates in other institutions for experience and training. Exchanges of younger men of some experience is even better and it is gratifying to know that for this active provision is being made. However, to succeed such interchange must be fair. Each must be willing to give of one's best, in the assurance of receiving similar treatment in return.

This method of manning the staff offers both difficulties and advantages. The gravest trouble is the turnover. It is heartbreaking to see a young man who has exhibited extraordinary teaching ability and promise go out into other work, leaving one saddled with the necessity of starting again from scratch in the task of training a beginner for the job. On the other hand, the method is educationally effective. It gives the satisfaction of seeing men towards whose development one has devoted time and energy go out into high professional achievement (even though in one's saner moments one realizes that the achievement was due to God-given capacity rather than to any contribution of one's own). However, the final satisfaction is the discovery of an occasional individual of adequate ability, who comes to love the work of the teacher and through permanent devotion of himself to it adds his contribution to the development of the profession and thereby of the civilization we try to serve.

THE ROLE OF THE ENGINEER OF TOMORROW*

By V. M. FAIRES

Agricultural and Mechanical College of Texas

Although we are living in an era of science, it is evident that those who are masters of society are not scientists; nor do they have scientific training. With amazingly few exceptions, their interest in science lies solely in its utilization for selfish ends, for profit and for power. "Why," say the executive and the politician, "why should I bother my head about scientific matters when for $2000 or less I can hire college-trained men with the requisite knowledge?" Why, indeed? The answer to this question is not immediately obvious. The answer, I think, lies hidden in the traditional attitude of what an engineer should be. My contention will be that we are rapidly approaching an era when those who manage civilization must have a background of science and scientists must have a background of the stuff that makes managers and governors.

Stuart Chase once said in effect, and there are many who agree with him, that the engineers should rule the country. Considering the predominant position of the products of technological science in our lives, I think this opinion is a reasonable inference and I hope not too naive. However, if Stuart Chase meant that engineers should be in control *now*, I fear he was wrong. Engineers are not yet prepared for this responsibility. They have not been trained in those elements which produce great men of public affairs. Technological civilization, therefore, is faced with the dilemma of statesmen untrained in technology, of technologists untrained in statesmanship.

Now, if Stuart Chase intended his statement to mean that engineers should be the only ruling statesmen, he is right only in part, because other professional classes should be included in this group. So, not only should we be prudent in extolling the virtues of the engineer of to-day, but we must be prepared to share future power and prestige with economists, with sociologists, and with scientists of all breeds. However, the implications of history reassure us of the ultimate status of engineers—a status that will be high indeed. This future status of the engineer, as I have envisioned it, is predicated upon a changing society resulting from elements of instability

* Presented at the 45th Annual Meeting, S. P. E. E., Cambridge, Mass., June 28–July 2, 1937.

in our present form of society, and upon society's indubitable dependence upon the knowledge of professional men.

Although we are conscious of living in a changing world, we are likely to think of the changes as being merely physical, changes typified by automobilies, radios, paved roads, photoelectric cells, air conditioning, automatic machines. More subtle and significant are the sub-surface changes in the basic conceptions of society, those unseen transformations in the ideas and manners of the people who are actuated by the more obvious material changes. A society which is so closely knit by new means of rapid transportation, by almost instantaneous means of communication, by a common heritage of scientific achievement, must evolve compatible customs, manners, and habits, congenial ideals and ideas. The evidence indicates that the machine has created an overstressed condition in the structure of society, a condition that must somehow be relieved. Sometimes, as history shows, the stress of new and unassimilated conditions, such as those born of the machine, becomes so great that the structure of society collapses. Revolution occurs. At another time, or possibly in another country at the same time, adjustment is piecemeal. The old order patches a weak point here and another there, until points of excessive stress are relieved.

Let us glance back through the records of history and search for situations that may throw light upon the trend of events to-day. In this brief review, we should note that peoples of other times had social ideals very different from ours; we should consider some of the changes which have occurred in civilizations before ours; and we should compare and contrast previous organizations of society with our own. Time does not permit an inquiry into the ramifications of the organization of any particular society. We can, however, choose phases to illustrate one point or another. For example, the Roman Republic was succeeded by an absolute monarchy, not because an absolute monarchy is better than a republic, but possibly because ambitions of empire in a whole people engendered extraordinary individual ambitions for power. These individual ambitions for power may have sprung in some manner from an intuitive realization that the far-flung Roman Empire could be held together only by a strong central authority in a position to act promptly and decisively. The usurpation of power may have been tolerated by the Roman people and the Senate because they were one and all sick of the bickerings of the triumvirate and the habitual civil wars that marked the last days of the Republic.

In our contemplation of the history of turbulent times, we must take care to search for the significant. That the late Czar was a fine old fellow, well-intentioned, innocent, and ignorant, and that

such a splendid gentleman was killed, should have little to do with our view of the Russian Revolution. Rather, we should try to discover the temper of the great mass of people who permitted or condoned, even though they did not agitate, the revolution. We might ask ourselves why a revolution occurred in Russia and not in England. Now, if we can see, even superficially, why certain changes in the form of society have occurred in the past, we may by a consideration of present trends forsee something of the form toward which our own society is evolving.

Consider for a moment the feudalistic order. Our elementary text books on history are wont to decry the evils of this system. The plight of the poor serf has been the subject of much sentimental effusion. Such elementary conceptions as these are derived from the history of the collapse of feudalism. At the inception of feudalism, there were marauding bands of outlanders, there were even neighboring barons who, surfeited with individualism, would prey upon the lands and persons of the defenseless peasants. What then was more natural (it is not a matter of right or wrong) than for these peasants to trade a share of their crops or a portion of their labor to a nearby baron in return for the protection of a fortress and an organized army? Such an agreement provided substantial benefits to both parties. However, there came a time when the country was no longer troubled with sporadic attacks from mobile bands of foreigners, when the feudalistic organization was so strong that it was no longer profitable for one baron to prey upon the domain of another. What then was more natural than that the serfs, having no need for the protection for which they paid by ardous labor, should rebel against the system. Certainly nothing was more natural than this rebellious attitude of the serfs, unless it was the attitude of the barons who did not relish losing the power and advantages of the *status quo*. Note that it is from this later stage of feudalism, when the struggle was bitter, that we ordinarily derive our impression of it. But remember that at one time it was the good way of life, and that it developed naturally from the conditions of the times.

Next let us consider a phase of the society existing prior to the industrial revolution and speculate about the factors affecting the organization of society. As the population increased and as the European civilization became more complicated, trade became a more important function of society. A flourishing trade is the stimulus for the growth of towns and cities which act as trading centers. In sparsely populated districts there is too small a demand for specialized services to warrant the development of distinctive skills. But if a large number of people are congregated in a small area, specialization of the workman is a natural consequence

and has certain advantages. For the protection of these specialized workmen, there was the Guild movement with its journeymen to serve outlying, less-populous districts. The Guilds became very powerful because the products of their members became the essence of a great world-wide trade. Eventually, the trading centers were large enough to justify mass production. Consequently, the more enterprising master workmen enlarged their businesses. These manufacturers, as they really were, began to employ only experienced journeymen. The further specialization of the journeymen according to the job performed seems to have been an early development in the handicraft factory. Contrary to what we usually think, mass production, at least of a kind, existed before our present machine age. Indeed, mass production is something of a natural concomitant of populations massed in trading centers—unless there happens to be some mitigating influence in the order of the society, as there was in ancient Athens where each freeman owned a platoon of household slaves.

When machines were first introduced, they were considered blessings because they could be operated by children. Shocking as it appears to us, the attitude of the late eighteenth century was that, with the aid of machines, children were "rendered capable of maintaining themselves at an early period of life, and of being useful to their parents and the community." It is not intended to imply that child labor was an outgrowth of the machine age. On the contrary, we may now say that the machine ordains complete abolition of child labor. Of course, time is necessary for realization of this prediction. History cannot be hurried. But it is obvious that man, with the assistance of power-driven machinery, can satisfy his wants with so little expenditure of his own energy, that he no longer needs child labor, and what he no longer needs is certain to disappear eventually.

As Lewis Mumford points out in his *Technics and Civilization,* without the steam engine, we should never have had the big factory. Without the big factory, we should never have been confronted with the problems of industrial monopoly and concentration. Without the big factory and the big machines in it, we might never have come to worship size as something inherently good. Without the big factory and the attendant necessity for the workers to read notices and instructions, we might never have had publicly supported schools. And so we might add that if science were not the common property of mankind, we should have no reason to suppose that those nations which are uniquely dependent on industry for life are doomed to experience recurring internal disasters until this unique dependence no longer exists.

Now, these remarks about particular phases of particular civilizations suggest that the less tangible elements of any civilization arise from the more obvious elements. Let us next consider some of the evidence which indicates an instability of the modern social order. There are a number of factors present in modern society which were substantially unimportant a century or more ago, among which are (1) a more common enjoyment of luxury goods, such as the automobile and radio, (2) an increasing significance of fixed charges as an element of cost of production, and (3) the urbanization of the larger proportion of the population. A detailed discussion of these factors and others which tend to increase instability would be no more than a rehash of the various ideas advanced to explain the depression. However, we should observe that the greater the number of people enjoying goods unessential to existence, the more vulnerable we are under the present organization of society. Those masses living on the fringe of luxury are the first who must retrench, and since their number is so great, the effect is necessarily an industrial disaster. Moreover, the dangers inherent in this marginal consumption of luxury goods are aggravated by the contemporary practice of buying these goods out of future income. We should observe, too, that the high fixed charges which are an integrable part of our modern, expensive industrial plants introduce an element of rigidity in prices which surely accentuates a depression and increases our economic instability. And finally, with the trend towards urbanization, more and more people are leaving regions where they might provide for themselves during periods of economic distress, and establishing themselves in regions where, lacking work, they must surely depend upon the rest of society for existence. These factors and many others were never before so significant as they are today. If more evidence is needed to show that we are living during an unusually critical period, we need look no further than the recent history of Europe with its revolutions and its dictators, its struggle to find a solution to the modern dilemma.

In this discussion I have intended to point out that the social organization is not a static thing, that it is continually changing, sometimes slowly, sometimes rapidly, that the time comes sooner or later when a social order which was once good becomes bad, and finally that there are many obvious evidences of a present instability, that we must be prepared for a rapidly changing scene in the years to come.

Now we may ask ourselves, "What is there in modern society which distinguishes it from social organisms which have preceded it, and which may yield a clue to the nature of our future development?" Certainly, the most significant distinguishing factor is

science. Only fifty years ago science, in its swaddling clothes which it has barely outgrown, was of little import in the life of the masses. To-day, every omen points to its continuously increasing influence in the life of the average man. And with the popularization of the products of science, we find that the methods of practicing science are undergoing revolutionary changes. A century and more ago, inventors and discoverers of scientific truth were individuals who usually towered high above mediocre humanity. To-day, I dare say, most of the valuable inventions and discoveries occur in laboratories where groups of men cooperate on a problem. Is it possible that the change in the manner of pursuing science is typical of the nature of other contemporary changes?

One of the consequential products of science is the machine. The effects of the machine on society have been aggravated by two factors: (1) a more comprehensive use of mechanical and electrical power, and (2) a more general utilization of the principles of so-called "scientific" management. We all know how these particular factors have resulted in a vast increase in the output of factories per man-hour of labor. Moreover, I think that you will concede that this increased productivity of labor is in itself a fundamental change, one of the most powerful forces acting upon the structure of modern society.

So let us agree, at least for the moment, that society is undergoing an evolution of major proportions and that the foremost motivating factor is science. Who makes the findings of science useful to society? The professional men, among them you and I. All professional men are included, for it is not only through technology that modern science is affecting us. The doctor and the sanitary expert guard our lives. The farmer needs not only the products of technology but also the services of the entomologist, the geneticist, the agronomist. Psychologists, economists, and other social scientists constitute influential professional classes because, by means of a factual approach to their problems, they are closely weaving their findings into the affairs of every day life. Indeed, the evidence suggests that society is about to divert its major energies from developing its scientific knowledge of the inorganic, the machine, to developing its knowledge of the organic; in particular, its knowledge of the human being.

The significance of this trend can be deduced, I think, by analogy. To maintain its great empire, Rome needed hardly soldiers and daring commanders. As a consequence, the policies and government of Rome were dominated by military men. To maintain and build up its commercial civilization, England needed rugged individuals willing to risk a shilling to gain a pound. As a consequence, the policies and government of England came to be

dominated by the commercialist. To maintain a modern industrial civilization, we need a vast army of professional men. Therefore, considering the significant position that science has acquired during the past fifty years, considering the concurrent growth in the number and importance of scientists and the appliers of science, and considering, too, the apparently inevitable continued expansion of science into the pattern of our every-day life, we must conclude that professional men are destined to attain roles of the highest degree in the conduct of public affairs. Indeed, this trend is already well established. There is probably in government to-day more professional intelligence than ever before. The fact that this intelligence is not being efficiently utilized in no way dims the significance of its presence or the hope that it holds for the future. We should not expect these professional men to displace the politician, but we may anticipate that the politician will be forced by circumstances to place greater dependence on the expert, and we may anticipate that more professionally-trained persons, other than lawyers, will become politicians.

Certainly, engineering is not the least important of the professions. Certainly, no professional class will have a more signficant role than the engineering group. It seems to me that no matter what may be the ultimate outcome of the contemporary evolution of society, the engineer will emerge as something of a keystone of the new structure. He will naturally be in demand for his technical skill. But as I said at the outset, I fear that the engineer is not prepared now to administer the will of the people. Society needs, not just engineers, not engineers who have only shed the careless empiricisms of yesterday, but engineers with the power of comprehending the social order, with the power of understanding the social implications of the machine. Society needs engineers with the power of seeing, not just an individual, but the individual and all his environment together. In justification of our present curricula, we often hear it said that industry is satisfied with our product. But to satisfy industry is not our sole obligation. We must—and this is fundamentally more important—we must satisfy society as well. If the engineer is able for his part to contribute only a technical skill, he will fall far short of society's expectations and demands. We, as educators of engineers, must somehow impart to our students an uncommon flexibility of mind, an eagerness to pry under the surface of life, a feel for the current of civilization.

To be sure, all this is not new to you. You are familiar with the activities of the Engineers' Council for Professional Development and the American Engineering Council; you listen to the constantly recurring agitation for a five-year curriculum, which is in

part symptomatic of a conscious or subconscious groping for a solution; you recall the recent widespread introduction of courses in the humanities in place of technical ones; and you are aware of the many words of warning that you have heard from the leaders of this Society.

Yet withal I feel that we are not moving fast enough. I feel that we ought to be admonished frequently on this matter, especially now that we may be lulled into a feeling of security and well-being because all our graduates are readily finding jobs. When our graduates are satisfied, we are prone to think that all is well. Perhaps the realization that civilization invariably changes to accommodate itself to new forces will aid our memory. During the period of exploitation, of constantly expanding markets, the mercantile class, with its jungle law of the survival of the fittest, performed an indispensable function. During the coming period of consolidation, of evolution, the engineer, and indeed all professional men must necessarily perform functions no less important. I am eager that the engineer be prepared for his part, that engineering educators forsee these potential developments.

CONFERENCE ON TESTS AND COMPREHENSIVE EXAMINATIONS *

DISCUSSION BY RICHARD H. FRAZIER

Massachusetts Institute of Technology

The program names this a conference on tests and comprehensive examinations. It is interesting to note the following:

a. The title of no paper uses the word "test."

b. The titles of all papers include the word "comprehensive."

c. Various kinds of examinations are called "comprehensive."

d. These "comprehensive examinations" appear at various levels in the curricula.

e. The "comprehensive examinations" aim to serve a variety of purposes.

I should like to elaborate somewhat upon the above observations. Professor Olmstead said that in connection with his examinations for licensing engineers, it was necessary to decide first, whether or not a comprehensive examination is necessary, and then, what character the examination should have. This procedure is not perhaps so illogical as it may sound, because in the present state of the terminology, a "comprehensive examination" may be anything that Professor Olmstead or any of the rest of us say that it is. The examination questions may be of the objective, essay, or problem type, or combinations and variations of those types. The examination may be comprehensive or "general" by dealing largely in generalities rather than in details and particulars. The examination may be limited to a subject, or it may include an entire field. The individual questions may be limited in scope, or each question may be in itself more or less comprehensive in scope. The examinations may require from a few hours to a few weeks of time; they may be written, or oral, or both; they may be closed book or open book or both. Outside examiners may or may not be used. The examinations may appear at the freshman, sophomore, junior or senior level or at several levels. Some examinations are used in connection with vocational guidance, some are used in association with honors courses, some are used in connection with the licensing of engineers, and so on.

* Annual Meeting, Society for the Promotion of Engineering Education, Cambridge, Mass., June 30, 1937.

The last item on the program is "Recommendations of the Conference as to further work of the Committee." I wish to suggest as a next step an endeavor to codify the various brands of examination now termed "comprehensive" in order that a mutually understandable terminology may be available. This work should be coupled with an endeavor to draw up specifications for each classification and statements of the general and special aims of each. I believe that underlying the specifications for all classes should be several closely-related criteria such as the following:

a. The examination should be "comprehensive" in that it tests the *comprehension,* and so encourages students to study for abiding understanding.

b. The examination should encourage correlation of the subject-matter of the curriculum.

c. The examination should emphasize the continuity of the educational process, in the face of the various terminal points created for system and convenience in teaching.

d. A quotation from William James should be kept in mind: "An 'uneducated' person is one who is non-plussed by all but the most habitual situations. On the contrary, one who is educated is able practically to extricate himself, by means of the examples with which his memory is stored, and of the abstract conceptions which he has acquired, from circumstances in which he was never placed before."

Whether we like it or not, no examination serves purely as a vehicle for appraisal; all examinations have influence in determining the mode of study. That is why many of them are so injurious. Some may serve as reasonably good measuring devices for what the examination has influenced the student to become, but perhaps the student should not be encouraged to get that way. It is of course important to have reasonably sound measurements of accomplishment; the matter of primary importance however is to give attention to the kind of standards which are set (sometimes inadvertently) by the manner in which these measurements are attempted.

EXAMINING IN THE PROFESSIONS*

By EDWARD S. JONES

University of Buffalo

During the past ten years colleges in the United States seem to have had a renaissance. They have been tending towards a new

* Presented at the Conference on Tests and Comprehensive Examinations, 45th Annual Meeting, S. P. E. E., June 30, 1937.

idealism, similar in fervor but different in kind from that found a century ago. The American college has been a composite of several variables: it has served in part as a character training institution built on the traditions of theological instruction, as an athletic and social center for what might be called personality building, and finally as a nucleus for our best intellectual heritage. It is this last ideal which has come to the front, and certainly one of the main motivators in this direction has been improved examining. This great interest in improved examining has naturally stimulated many professional schools to inquire into their examining programs. However, I know of no very systematic survey of professional examining as such.

In less than ten years' time over a hundred and fifty colleges have developed a plan of examining their students at the time of graduation particularly in their major department, requiring such an examination for graduation or at least for honors ratings. In many of these colleges the entire rating of a student in honors is based on the results of this examination. Professors who have given these examinations and alumni who have taken them report favorably on their stimulating value in the direction of improved scholarship. The senior year of college is no longer the loafing period; it is the time when material from several courses must be brought together in advanced seminars or tutorially, when gaps must be filled in by independent reading so that one is prepared for a final exhibition of intellectual attainment in a field.

This new fervor for improved examining is very largely a duplication of the experience in English universities more than a hundred years ago. At that time first in Cambridge, in science and and mathematics, later in Oxford, major comprehensive examination began to be administered for all honors degrees. These challenging examinations were not only important scholastically; they became the bulwark of the English Civil Service system and it was widely heralded that high honors in either of these institutions would guarantee one of the choice positions of the empire. This vocational advantage is significant because it is doubtful whether the English would have continued their enthusiasm for such rigorous examining procedures unless there had been practical benefits arising therefrom. The material on which students were examined, mainly the classics and mathematics, had practically no specific bearing on the work which they were to do later; the examination was a test of scholastic proficiency. This is probably a composite of at least two factors—sheer innate intelligence on the one hand, and effort and moral integrity on the other. The civil service appointments were, therefore, made on the theory that he who studies

best in the classics will study correspondingly well in the civic problems of England.

The French have also used their university examinations as strict selective devices for teaching and some government posts. In a sense then the English and French university comprehensive examinations have been professional examinations.* A high rating in them has led to professional careers.

The most important aspect of these examinations was their unquestioned inspirational value in behalf of scholarship. Instead of attending lectures, students in Oxford by 1850 learned to read and study independently, and to pay tutors well to evaluate their basic information. The ablest minds began to be stretched towards new powers of expression, or capacities for analysis and generalization. Attending group discussions or lectures was for them a waste of time.

Aims of Examinations

In the examinations in this country we find two fundamentally different attitudes that are so antithetical that they determine differing philosophies. One attitude is that examinations are to prod or scare the poorer elements of a group into hard work. They represent unpleasantness and discipline, and bring the great majority up to certain minimum standards. The New York State Regents system has been accused of this tendency, and I think unjustly. The second type of emphasis is concerned with the examination of students for honors rating. The examination is a goal or prize to be attained. In this type of examining there need be little unpleasantness, particularly if it is known that students can pass subjects on low minimum requirements, that the main purpose is to differentiate several levels of ability, in order to grant honors distinctions. In this country, as in England, final comprehensive examinations in college are generally of the honors type, designed mainly to differentiate degrees of honor. Particularly is this true when outside examiners are used—since outsiders prefer not to trip students up. Rather they are inclined to allow students to set their own examination, merely suggesting general outlines of topics.

These terminal comprehensive examinations have been found useful not only because they encourage superior students beyond the ordinary requirements; they have also helped professors and students to unify or integrate their subject matter. Most important of all, perhaps, they have helped colleges to question the objectives of a college education. They have asked, "Just what is our ultimate goal?" When we set up terminal examinations as

* The Chinese operated on the same philosophy nearly two thousand years ago.

goals and standards, we naturally must reorganize curricula and methods of instruction.

The growth of the professions in this country and abroad has been largely dependent on the development of professional examinations. Mr. Carr-Saunders * and Mr. Wilson, in their stimulating analysis of professional associations in England throughout the 19th century, suggest that the main impetus for the advancement of professions came through these protective associations. Ostensibly to protect the public against mal-practise, rules and standards were set up which also served to protect the members of the profession. Examinations were proposed, at first largely oral and decidedly crude. Later, as the onus of examining was felt in local associations, the entire burden of this work was handed on gladly to university training centers and finally to the state.

The British have usually tried to guard their examinations, so that they would be impersonal and respectable. Questions have been available for inspection for all comers. Many public debates and even government investigations have centered in the problem of improving examinations. It is generally accepted as a principle that no instructor can properly examine his own students; they must be interrogated by some outsider. The English have been less interested in the concept of scientific reliability—that is, measuring the same thing each time—than they have in validity and fairness. Professional examinations have come in for their share of criticism and improvement, under the influence of the continually repeated question, "Are we examining in the right way?". The chief criticism on the part of the public in England has been that the professions have been too highly guarded by expensive training so that the poor man's son has no chance to pass the examinations.

Methods

Assuming that some type of major terminal examination is desirable in a professional field, where should we place the emphasis? I am confident that there is no simple answer to this question and that every so-called professional outlet would wish to emphasize its own objectives. Let me illustrate by two extremes. Recently a young Oxford law graduate visited this country and reported an experience which he had while seated at an Oxford tea table. During the period of his meal, a famous British lord dropped over to introduce himself. He chatted informally for an hour or so with this personage of great reputation, discussing political, economic and ethical questions in general or specific problems pending in the empire. It was not until the great gentleman had left

* "The Professions," London, 1933.

that the young barrister suddenly realized that he had been examined for entrance into one of the Inns of Court and that his entire future had depended on that hour's oral interview. Fortunately it was successful; the examination was passed. Who can estimate reliabilities statistically in a case of this sort? Commenting on some of the bar examinations in this country this young lawyer said they were trivial, if not worthless, in comparison. What is wanted in a lawyer in England is sound moral judgment, and attitudes in accord with British principles.

The other extreme case is that of certain State examinations given to nurses and pharmacy graduates for certification in a number of states in this country. Fully 80 per cent are very highly specific questions, with less than 10 per cent which can conceivably be referred to as problems or free discussions. In one State examination in pharmacy the question asked was, "Describe the first and last drug mentioned in the *National Pharmacopeoia.*" A large percentage of the examinations given the nurses were of the short-answer type, requiring very specific memorizations. Fully 80 per cent of items both in the pharmacy and dentistry fields were specific points chiselled out of standard textbooks. Problem solving or thinking over new situations was rare indeed.

Here we have two extremes, the examination for the Inns of Court in England as compared to the examination for certain of our professions in this country.

Most of our comprehensive examining would fall in between these two extremes of oral informality—with very little attempt to control a rigid standard of attainment—on the one hand, and highly specific memorizations on the other. In our colleges in fact the major emphasis has been placed on an intermediate form of controlled discussion. Nearly 60 per cent of questions in the humanities and social sciences are of this type. The terms "discuss," "compare," "outline," "show reasons for," are all typical of the starting of these discussion questions. Incidentally they are seriously objected to by the advocates of new type or short-form testing, in that they are so difficult to evaluate fairly.

I believe it is possible to differentiate quite clearly four different types of recall questions—each with extensive variations—on the basis of which any university or professional group might care to analyze its examinations:

A. Specific facts. These include identities, definitions, proper name associations; ten or more items being possible in an hour. (Most of these items are easily worked up into short-form new-type tests.)

B. Controlled discussion. *E.g.* "Explain the difference between

armature reaction and armature reactance in a direct current machine."

C. Free uncontrolled discussions and essays. The Harvard quotation questions in the History and Economics departments are good illustrations. These would require an hour more or less, possibly several hours.

D. Problems. These are presumably quantitative and original, but occasionally items are referred to as problems when they are standard textbook formulae and could be memorized. Most engineering examination problems do not require more than 15 or 20 minutes.

The question is inevitably raised, "What should a professional examination be like?" If it is the druggist's business to stand behind a counter and answer specific discrete questions or read symbols written out by doctors, perhaps his professional examination should be of the discrete factual type. If, on the other hand, he is expected to be a well-educated person, competent to talk freely about poisons or to analyze properties of new drugs, his examination should obviously be much broader. Regarding the education of nurses, one important hospital superintendent in Buffalo has made the remark concerning nurses, "We don't want them to use their heads. We just want them to take orders." Of course this position can be strongly challenged.

Examining in engineering as well as in pure science naturally veers towards problem solving, although there are striking differences between instructors and institutions. One of the most stimulating professors of college physics to-day is weak in problem solving and does not stress it for his students, and yet a large percentage of his undergraduate students obtain Ph.D. degrees in physics ultimately. A chemistry course may be taught largely as a clear descriptive outline with formulæ and explanations completely recorded for memorization or it may be a succession of problems and how formulæ are developed. Occasionally this difference is illustrated by a boy who gets a 100 in a New York State Regents chemistry examination in high school, then fails in a more analytic college chemistry course.

Examinations in Engineering

As in the case of other professional examinations the impulse for engineering comprehensive examinations arises out of the interest in protecting a professional group as well as protecting the public. It is my understanding that the architects originally organized to influence state officials to recognize their contribution to a new building by state regulations. This led to state-endorsed

examinations with subsequent certification. Following the architects, engineering groups have fallen in line. Similarly the actuarial experts, the accountants and other groups have established themselves professionally in the eyes of the state by law. It is apparent from the early examinations in the field of engineering in New York State that the emphasis here is very different from that found in nursing and the pharmacy professions. Not much over 20 per cent of the items were specific factual explanations or definitions, whereas 60 per cent in one sampling were problems. Nearly all of these are practical specific problems typical of the profession itself. Only about 10 per cent could be classified as discussions or essay type questions, perhaps because of the natural distrust of verbalization on the part of the mathematician.

If professional state examinations are primarily for the purpose of disqualifying those who are most inferior, their main emphasis should, no doubt, be on specific questions and problems which are actual every day samplings of the engineer's life experience. If, on the other hand, the examination is to test capacity for new lines of thought, ability to organize research—in other words the honors type of mind as it is known in Europe and this country—then the examination should obviously include other broader questions. I am personally unfamiliar with typical engineering examinations in universities, except slightly with the excellent work done in certain departments at the Massachusetts Institute of Technology. I understand that here, as in some science departments at Cambridge, England, honors candidates are given original projects or problems on which they work for hours or days. This is vastly different from a two to four hour examination, which is not much more than a gesture, such as has been adopted by a number of colleges of arts and sciences in their comprehensive examinations.

One might raise the question: if states or large associations are to give their own professional examinations why should a college bother to do it? The national medical board of examiners is a case in point. Several medical schools are either requiring or urging their seniors to take these national board examinations which give them a right to practise in all states. These tests are far superior to the average state examination in their emphasis on new situations and problems, in contrast to memorized formula or typical text-book questions. Science is universal and a single national centralized examining board seems to be effective in this field. I am convinced, after surveying a large number of state board examinations in medicine, dentistry and pharmacy, that a single national board examination or at least regional examinations would be desirable. It implies more time and care for the examining function, and a better-trained, more up-to-date examiner, freed from the ruts into which

provincial examiners, without constant criticism, so easily fall. There is plenty of room for local experimentation in examining in the universities.

Objections to Comprehensive Examining

There is already a wave of discontent in certain colleges in this country regarding the comprehensive examinations in colleges of arts and sciences. Many people do not feel that these terminal tests accomplish anything that is not accomplished in good classroom work. It is my belief that reasons for this discontent are multiple. Much of the criticism comes from people who have never tried these examinations seriously. Unless such examinations are very carefully worked out by professors, they are probably not worth much. Unless the questions are to some extent different, broader and more searching, or inclusive of more fields, the comprehensives do not aid materially to stimulate students or professors.

A second difficulty is the usual absence of outside examiners or outside examining influences. If students know that they are to be examined only by professors under whom they have had two or three classes already, they are not likely to fill up many gaps in their background. The final comprehensive is just one more test which is not very likely to be different from questions they have already run into. If, however, the examiner is from another institution or at least not well known, the whole atmosphere of examining changes. Students and teachers begin to work together towards a common goal, against which both will in a sense be tested. Thirdly, presidents and deans are frequently uninterested or feel loath to require extra duties from their teaching staff, or extra money for outside examining. So long as comprehensive examining has to be something drawn on as a regular routine with a full load of teaching, it is not likely to be done well. Perhaps there will be three or four years of enthusiasm but this will wane, particularly if no important official pays special attention to it, and if examiners are not rewarded for excellence *as examiners*.

One cannot discuss comprehensive examining without running into the issue of the new-type short-form testing. There are signs that professional fields, more than our colleges of arts and sciences, are likely to pay considerable attention to these new types of short-form examining. I mean, of course, marking items True-or-False; or selecting one response from several; or matching items. In nursing such examinations are becoming almost universal; in pharmacy, dentistry and medicine the advocates of short-form examining are winning strong support. The chief arguments in favor of such

examinations have perhaps been stated so often that they should not be repeated. Mr. I. L. Kandel in his recent book, "Examinations and their Substitutes," * strongly defends them. A much wider range of topics can be covered in less time and with greater reliability. The objectivity and freedom from bias and lapses of attention while grading are all points which cannot be ignored. The one great point of doubt in the minds of many is the question of validity. Granted the greater reliability of short-form testing, are these tests as valid in evaluating the most important objectives? If they are not as valid, if for example it is known that less than 10 per cent of ordinary standardized items deal with new situations or generalizations which are relatively free from textbook sterotyping, enthusiasm for them may rapidly decline. Dr. Ralph Tyler of Ohio State University has shown that the capacity to generalize with new situations is not closely related to one's memory of specific facts.

Educational statisticians have juggled with these two concepts of Reliability and Validity, some assuming that if a test is reliable it is automatically valid. This is absurd as saying that the weight of a football player is his most valid index of ability just because it is a reliable measure. Height is still less likely to fluctuate from time to time, yet no one would argue that weight or height were valid measures of football efficiency.

In the field of engineering it is hard to see how short-form testing could gain the prominence which it has received in many of our large western arts colleges. It isn't enough to know items by heart or to infer which of several responses is correct; one must solve original problems. One must manipulate and organize. It isn't enough to know textbooks. And yet many people today consider that the only true comprehensive examination is one built up with the short-form techniques.

To summarize: So far as I know there has been no adequate survey of professional examinations in this country. Each profession has become more conscious of the need of effective examinations, partly to select the best candidates from a miscellaneous group in order to improve the profession itself, partly to protect present members from competitors less well trained. The improvement of examining reacts inevitably upon the type of instruction and the general level of the profession. The type of preferred examination will normally be related to the chief objectives in the profession. If a *pass* level of accomplishment, if a fixed standard, is desired, the questions will tend to be stereotyped, requiring more memory work than problem solving or free discussion. Out of such standardized mediocrity, vested interest will be built, but also,

* Carnegie Foundation for the Advancement of Teaching, 1936, pp. 183.

as suggested by Harold J. Laski,* a decline in the profession will follow since the primary motive is selfish benefit from one's professional status.

If honors work, research ability, or the capacity to organize is of primary interest, there is room for unlimited expansion in the variety of examination questions, and in the time allowed for their solution. When this is attended to, presumably in national examinations, new professional levels will arise. The potential fellowship man will stand out and the community will benefit correspondingly. New types of honors examining will inevitably lead to a reorganized professional education.

SOPHOMORE COMPREHENSIVE EXAMINATIONS AT LEHIGH UNIVERSITY †

By CHARLES W. SIMMONS [1] and BRADLEY STOUGHTON [2]

A comprehensive engineering examination at the end of the sophomore year was given at Lehigh University for the first time in the spring of 1928 in pursuance of advance notice given in the 1926 catalog of the University, as follows:

> At the close of the second year a comprehensive examination is required on the work of the first two years, and a student's admission to the junior year (in engineering) is based upon (*a*) his scholastic record for the first two years, (*b*) the results of his comprehensive examination, (*c*) his aptitude for engineering work as determined by his instructors' estimates of his ability to think, of his interest in the subjects taken, and of his accuracy and industry.

No numerical data were then available as to the critical scholastic record or the standing in the comprehensive examination which should be used for the purpose mentioned in the previous paragraph, and the experience of the years 1928 and 1929 showed that it was an injustice to the students to prohibit their continuance in engineering on the basis of the tests then in vogue. Therefore, advisory and not mandatory action has been our subsequent practice, although recent improved comprehensive examinations and the results of the statistical study given herewith in Table I, II, and III have led a Committee composed of the Dean of the University and the heads of engineering curricula to formulate action of a

* *Harper's*, Vol. 171, p. 676, 1935.

† Presented at the Conference on Tests and Comprehensive Examinations, 45th Annual Meeting, S. P. E. E., June 30, 1937.

[1] Chairman, Sophomore Comprehensive Examination Committee, Lehigh College of Engineering.

[2] Dean, College of Engineering.

mandatory character to receive early consideration. In 1930 the Carnegie college achievement test was applied at this and other universities in Pennsylvania and was substituted here for the sophomore comprehensive. In 1931 a Committee on Sophomore Engineering Comprehensive Examinations was appointed and has been studying the problem ever since. The result has been the formulation of a type of examination in advance of the original proposals. Such an examination must of necessity be developed to meet the specific needs of the individual university, and satisfactory results cannot reasonably be expected in a period of less than five or six years. This is due to the fact that it requires research and modifications to develop a satisfactory examination and then additional years to provide data from which conclusions can be drawn: In other words, scholastic achievement must be available for a minimum of two graduating classes which have taken the examinations. The development to date embodies a comprehensive examination for sophomore engineering students given each year in April to all students who have acquired second semester sophomore standing. The examination occupies one day, from 8 to 12 and 2 to 4.

The examination is made up of 88 questions in the fields of Chemistry, Mathematics, and Physics, formulated by the eight engineering departments and approved by the service departments of Chemistry, Physics, and Mathematics, and by the committee. The questions as formulated are intended to test the student's ability to apply information of a basic character to engineering problems rather than to state facts from memory. Thus, for example, the Electrical Engineering department has questions in chemistry relating to electrodeposition, or the Chemical Engineering department asks for the mathematical solution of an equation used in the study of filtration. Obviously, the questions should be capable of solution in an average time of four minutes each. Experience so far has shown that the types of questions known as "true-false" or "filling-in-blank" have given inferior results.

The questions are graded by the departments submitting them, using a prepared form, such as that appended hereto, which divides the questions under the general headings of Chemistry, Mathematics, Mechanics, Light, Heat, and Sound, Electricity and Magnetism, and Gas Laws and Specific Gravity. This form facilitates the final statistical analysis. The head of each department is subsequently provided with a compilation indicating the position of each of the students in his own group, as well as in the entire class, for the complete examination and for each of the particular subjects indicated.

Each year a statistical analysis of the value of each question in the examination, based on a comparison of the averages of the two

highest papers from each of the eight departments with an average of the two lowest papers, has been made. In this way, the weaker type of questions has been discovered and eliminated. For example, any question in which the lower group made an average of better than 50 per cent must be considered as too easy a question, and any question in which there is not a spread of 30 points between the highest and lowest marks is not considered a significant question. Based on a satisfactory spread from this analysis, the examination has been developed from a record of 76 per cent acceptable question in 1932 to an almost perfect examination in 1936, where only one question out of the 88 was unsatisfactory. Such a development study results in time in a type of examination showing highly satisfactory spread in all phases. Thus, for example, in 1935 we had the following interesting spread:

	High Man	Low Man	Median Man
Entire examination	85.5%	17.3%	45.4%
Chemistry	90.5%	2.7%	45.0%
Mathematics	88.5%	7.0%	41.0%

Too much emphasis cannot be placed upon the importance of developing a satisfactory type of examination. This development must go hand in hand with a study of the results achieved by the sophomores in their junior and senior years in the Engineering College. Then, and only then, can standards of elimination be set up which will spare the student two wasted, or partially wasted, years and raise the scholastic standards of the College. More important than this is perhaps the accumulation of data upon the basis of which students may be guided into that line of study for which they have more aptitude than they have for the studies of the Engineering College.

We believe that the results of our experience and investigations here, over a period of ten years of study, prove the possibility of an important advance in the effectiveness and value of engineering education. We hope to continue the study under the combined guidance of the departments of education, psychology, and engineering, to the end that Lehigh and all engineering colleges may develop a procedure which will exclude from the junior and senior years those students whose best interests will be furthered in some other field of study. The correlation described on page 382, and in Tables I, II, and III, indicate that 12.6 per cent of the students in engineering should withdraw from the College of Engineering at the end of the sophomore year for their own good, and for the good of the College. This is an important advance. Admittedly there

are other students, not disclosed by this procedure, who fail in their junior and senior years. Are these failures due to inability to master the work of the advanced years, not disclosed in the first two years, or are they caused by slackening of effort or earnestness or intellectual application, or a change of interest? Our studies have not yet gone far enough to answer these questions. We believe that research in this field will yield results of value. It is possible, even probable, that study and research may develop even a better hurdle than the one we have so far been able to set up. Admittedly the first consideration should be justice to the students and the serving of their best interests by wise guidance. Also, it is admitted that whatever lowers the scholastic standards of the institution impairs its usefulness to its students and graduates.

TABLE I

1933 Comprehensive Examination (N.B. 191 took this exam.)

Record of Lowest 20 Per Cent in Each Curriculum

Column 1	2	3	4	5	6	7	8
Curriculum	Total No. in this 20 Per Cent	Total in Col. 2 Whose Scholastic Average for 1–4 was Less than 1.50	Total in Col. 3 Who Graduated on Time from Engineering	Total in Col. 3 Who Graduated Late from Engineering	Total in Col. 2 Whose Scholastic Average for 1–4 was More than 1.50	Total in Col. 6 Who Graduated on Time from Engineering	Total in Col. 6 Who Graduated Late from Engineering
Chemical Engineering	9	6	0	2*	3	1	1
Civil Engineering	5	4	0	0	1	1	0
Electrical Engineering	6	5	0	2	1	1	0
Engineering Physics	1†	0	0	0	1	0	0
Industrial Engineering	5	2	1‡	1	3	2	1
Mechanical Engineering	6	4	0	2	2	2	0
Metallurgical Engineering	2	1	0	0	1	1	0
Mining Engineering	2	1	0	1	1	1	0
Totals	36	23	1‡	8	13	9	2

* One of these 2 students changed to Arts and graduated late there.

† The record of No. 2 is not available.

‡ Had not taken Math. 4 and 5 or Phys. 4, 5, 6, 7.

General Effectiveness of Sophomore Comprehensive Examinations at Lehigh University

Starting with the comprehensive examination of April, 1933, as being the first to be developed with reasonably acceptable questions, namely 88 per cent, and including the examinations of 1933, 1934, and 1935, the correlation between the results of examinations, the scholastic records of the students in their freshman and sophomore years, and their ability to graduate are given in Tables I, II, and III herewith.

We may summarize these results by saying that a total of 538 men took the three examinations; 110 of these 538 were in the lowest

fifth of all the men in their individual curricula. Sixty-eight of these 110 (61.8 per cent) were both in the lowest fifth and also had a scholastic average of less than 1.50 on a scale of 4.00. Sixty-eight is 12.6 per cent of 538. Only 3 of these 68 (4.4 per cent) graduated from the College of Engineering in their original class, and each of these 3 had deficiencies in Mathematics and Physics, which made their taking the comprehensive examination at the time when they did so a doubtful project.

On the other hand, 42 of these 110 students (38.2 per cent) were in the lowest fifth in the comprehensive examination, but had a scholastic average for their freshman and sophomore years of better

TABLE II

1934 COMPREHENSIVE EXAMINATION (N.B. 182 took this exam.)

Record of Lowest 20 Per Cent in Each Curriculum

Column 1	2	3	4	5	6	7	8
Curriculum	Total No. in this 20 Per Cent	Total in Col. 2 Whose Scholastic Average for 1–4 was Less than 1.50	Total in Col. 3 Who Graduated on Time from Engineering	Total in Col. 3 Who Graduated Late from Engineering	Total in Col. 2 Whose Scholastic Average for 1–4 was More than 1.50	Total in Col. 6 Who Graduated on Time from Engineering	Total in Col. 6 Who Graduated Late from Engineering
Chemical Engineering	15	9	0	1	6	3	0
Civil Engineering	4	1	0	0	3	2	0
Electrical Engineering	6	3	1*	0	3	2	1
Engineering Physics	1	0	0	0	1	0	0
Industrial Engineering	6	5	0	1	1	1	0
Mechanical Engineering	6	4	0†	0	2	2	0
Metallurgical Engineering	3	2	0	0	1	0	1
Mining Engineering	2	1	0	0	1	0	0
TOTALS	43	25	1*	2	18	10	2

* Psych. 78; on probation June, 1934. His soph. year was inexplicably bad. He had F in Math. 5 and had never taken Phys. 4 and 5.

† Entered with advanced standing; changed M.E. to I.E., then to Business College.

than 1.50. Twenty-six of these 42 (61.9 per cent) graduated in engineering with their class.

These tables show that the records made in the comprehensive examination, taken by themselves, are not conclusive evidence of ability or inability to graduate satisfactorily from the Engineering College. Several independent studies at Lehigh University have shown that scholastic achievement during the freshman and sophomore years, taken by itself, is not conclusive evidence of scholastic achievement which will be made during the junior and senior years.

Tables I, II, and III indicate that low ranking in the comprehensive examination, taken in combination with a low scholastic achievement during freshman and sophomore years, is together a 95 per cent indication of inability to graduate on time.

True, a few such students may hang on and graduate late, but experience shows that these students are not using their time to their own best advantage in the Engineering College and are a detriment to the standards of the College and a handicap to their fellow students. For their own good, and for the good of the College, they should be forced either:

1. To leave the College of Engineering at the end of the sophomore year, or else
2. To repeat the work of the freshman and sophomore years in Mathematics, Physics, and Chemistry, in which they have obtained a scholastic mark of less than 70 per cent before they go on to their junior work.

TABLE III

1935 COMPREHENSIVE EXAMINATION (N.B. 165 took this exam.)

Record of Lowest 20 Per Cent in Each Curriculum

Column 1	2	3	4	5	6
Curriculum	Total No. in this 20 Per Cent	Total in Col. 2 Whose Scholastic Average for 1–4 was Less than 1.50	Total in Col. 3 Who Graduate in June, 1937, from Engineering	Total in Col. 2 Whose Scholastic Average for 1–4 was More than 1.50	Total in Col. 5 Who Graduate in June, 1937, from Engineering
Chemical Engineering	10	5	0	5	2
Civil Engineering	3	0	0	3	3
Electrical Engineering	4	4	0	0	0
Engineering Physics	1	0	0	1	1
Industrial Engineering	4	4	1*	0	0
Mechanical Engineering	5	4	0	1	0
Metallurgical Engineering	3	3	0	0	0
Mining Engineer	1	0	0	1	1
TOTALS	31	20	1*	11	7

* Entered with advanced standing and therefore should not be correlated with the rest. He had 47 hours advanced standing when he entered from Stevens in September, 1934, and therefore had not so many hours to complete in order to graduate with his class.

The disposition of these cases, however, should not be automatic and inflexible but should be determined after study by a sufficient number of their teachers and an appropriate committee. In other words, we come now to basis (*c*) in the 1926 Register. For example, 3 students of low comprehensive and scholastic grade, among the 68 listed in Col. 3 of Tables I, II, and III, nevertheless graduated with their fellows. But, as indicated by the reference to footnotes in Col. 4, each of them had some special reason. On the basis of these special reasons, consideration should, and would, be given them by their instructors and a reviewing committee.

Before collecting the data given herewith in Tables I, II, and III, attempts had been made to study the effectiveness of the comprehen-

sive examinations. For example, the records of all the low men in the examination were studied in relation to whether they were ever subsequently placed on scholastic probation. This yielded information of much significance, but no definite and conclusive character justifying general action applicable to all students of low comprehensive grades. Attempts were also made to correlate comprehensive examination records with subsequent scholastic records. Again the data were significant but not entirely consistent.

The data given in Tables I, II, and III seem to indicate that a useful hurdle exists in the combination of a student's previous scholastic record together with the results of the right type of comprehensive examination and with his instructors' estimate of his aptitude for engineering work.

For information, we give herewith some questions typical of the different divisions of the comprehensive examination which have been found to be satisfactory. We also append a copy of the grading form used for the examination. In this form the upper table indicates the departmental or curriculum sources of questions, and the lower table indicates the classification of the questions.

SOPHOMORE ENGINEERING COMPREHENSIVE EXAMINATION (1935)

Last Name		First Name		Initial		Curriculum	
Ch. E.	C. E.	E. E.	Eng. Phy.	I. E.	M. E.	Met. E.	E. Min.
1 10	*2* 10	*3* 7	*4* 10	*5* 10	*6* 8	*7* 10	*8* 10
9 10	*10* 10	*11* 10	*12* 10	*13* 10	*14* 9	*15* 7	*16* 10
17 0	*18* 10	*19* 10	*20* 10	*21* 10	*22* 10	*23* 10	*24* 10
25 10	*26* 0	*27* 10	*28* 10	*29* 10	*30* 10	*31* 10	*32* 10
33 10	*34* 4	*35* 10	*36* 7	*37* 0	*38* 10	*39* 10	*40* 0
41 8	*42* 10	*43* 9	*44* 8	*45* 8	*46* 10	*47* 7	*48* 9
49 5	*50* 10	*51* 10	*52* 10	*53* 5	*54* 10	*55* 10	*56* 10
57 10	*58* 10	*59* 9	*60* 6	*61* 10	*62* 10	*63* 8	*64* 5
65 10	*66* 0	*67* 10	*68* 8	*69* 9	*70* 10	*71* 10	*72* 4
73 5	*74* 10	*75* 10	*76* 10	*77* 10	*78* 6	*79* 10	*80* 10
81 10	*82* 0	*83* 10	*84* 8	*85* 6	*86* 10	*87* 10	*88* 0

Totals 745. No. in curriculum 48. Final percentage grade 847. Total sophomores 165. Rank in curr. 1. Rank in sophomores 2.

Chem.	Chem.	Math.	Math.	Mech.	Units, Etc.	Light, Heat	Gas Laws	Elec. and Mag.	Spec. G.
1 10	*55* 10	*4* 10	*50* 10	*2* 10	*6* 8	*7* 10	*37* 0	*3* 7	*23* 10
5 10	*57* 10	*8* 10	*53* 5	*10* 10	*21* 10	*15* 7	*38* 10	*11* 10	*26* 0
9 10	*59* 9	*14* 9	*58* 10	*28* 10	*29* 10	*20* 10	*41* 8	*35* 10	*32* 10
12 10	*64* 5	*16* 10	*61* 10	*48* 9	*36* 7	*25* 10	*46* 10	*43* 9	*80* 10
13 10	*65* 10	*18* 10	*63* 8	*52* 10	*85* 6	*30* 10	*56* 10	*44* 8	
17 0	*67* 10	*19* 10	*69* 9	*56* 10		*31* 10	*78* 6	*45* 8	
24 10	*70* 10	*22* 10	*71* 10	*66* 0		*54* 10		*51* 10	
33 10	*75* 10	*27* 10	*73* 5	*74* 10		*62* 10		*60* 6	
39 10	*81* 10	*34* 4	*82* 0	*77* 10		*72* 4		*68* 8	
47 7	*83* 10	*40* 0		*88* 0		*84* 8		*76* 10	
49 5	*87* 10	*42* 10				*86* 10		*79* 10	
Total, 196		160		79	41	99	44	96	30
Percentage, 89.1		80.0		79.0	82.0	90.0	73.3	87.3	75.0
Rank in curr., 2		2		1	1	1	8	1	12
Rank in soph., 2		9		5	1	3	10	2	29

Numbers in italics refer to question numbers; numbers in Roman type are examination grades on the basis of 10 = perfect.

Typical Questions

1. A block of stone (sp. gr. = 2.4) is suspended by a wire in a tank of fresh water where it is completely immersed. The pull on the wire is 87.5 lb. What is the weight of the stone?

2. A coal seam dips due North at an angle of 30°. A slope is driven N. 30° E. along the seam. What is its grade per cent? (Sin 30° = .5000, Cos 30° = .866, Tan 30° = .5774.)

3. A flask while open to the air is heated from room temperature (21° C.) to 200° C. and the barometric pressure is 755 mm. The flask is then stoppered and cooled to 28° C. Calculate the final pressure in the flask, neglecting expansion of the flask.

4. A gasoline engine develops 5 horsepower for a one hour period at an efficiency of 18 per cent. Gasoline of 150,000 B.t.u. per gallon is used. Cost per gallon, 15 cents. 778 ft. lb. = 1 B.t.u., 1 hp. = 550 ft. lb. per second. Find (*a*) cost of gasoline for the run; (*b*) theoretical height to which a 6600 pound block could be raised by the engine.

5. A straight timber, 30 ft. long, is held in a horizontal position by a support at one end and by another support 20 ft. away. The

timber carries a 12 in. wall of brick which varies in height uniformly from zero at the supporting end to 10 ft. at the other (overhanging) end. Compute the supporting forces acting on the timber. Brickwork weighs 120 lbs. per cu. ft. Neglect the weight of the timber.

6. A battery is connected in series with an ammeter of negligible resistance and a rheostat. When the rheostat is set at zero resistance the ammeter reads 15 amperes. When the rheostat is set at 12 ohms the ammeter reads 5 amperes. What is the electromotive force of the battery?

7. A current of 1 ampere is used in the electrolytic deposition of copper from a cupric sulphate solution. Calculate the weight of copper deposited in 2.5 hours. At wt. Cu, 63.57.

REPORT ON CONFERENCE OF SECTIONS AND BRANCHES

The meeting was held July 1, 1937, in connection with the annual meeting of the Society. The Chairman, Dean G. W, Case, University of New Hampshire, explained that the purpose of the conference was to provide an opportunity for the exchange of information regarding methods of conducting sections and branches, programs for making these meetings most valuable and interesting, problems encountered and their solutions, and suggestions for future meetings.

The following topics were presented by the speakers noted.

MAKING SECTIONS WAKE UP AND LIVE

CARL S. ELL, *Chairman, New England Section,*

Northeastern University

After stating his belief that such factors as geographical distribution might render the experience of one section of little value to another, Dr. Ell outlined briefly the history of the New England Section.

From the time of its organization in 1921 until 1930 this section met twice each year. Since the spring meeting came so closely upon the annual meeting of the National Society, it was decided in 1930 to omit the spring meeting and to hold only one meeting of the New England Section each year, this to be a fall meeting in October. (This change was made with the thought of encouraging the members to attend the annual summer meeting of the parent society.)

The attendance at the meetings of the New England Section from 1921 to 1933 varied from a minimum of 48 to a maximum of 115. In 1934, when the idea of morning conference meetings and definite afternoon program was first inaugurated, the attendance was increased to 189. The attendance in 1935 under the program was 312 and in 1936 the attendance was 254 although the host institution was located over 200 miles from the great majority of the membership.

Previous to 1935 the responsibility of the entire program fell upon the shoulders of the officers of the Section. Now a pro-

gram committee is assigned to this duty. This committee, which is appointed immediately following the annual fall meeting, decides upon its program, secures the speakers, and is in a position to send out full information to the members far in advance of the time of the meeting.

The meetings are scheduled for one day only. In the morning each conference section has its respective speakers and discussions. A luncheon at noon is followed by a brief program. In the afternoon there is a general session with one speaker and limited discussion, followed by inspection trips to the laboratories of the host institution. Sometimes there is a musicale or tea before the evening dinner. The evening program consists of a banquet with a speaker on some non-technical subject of general interest to both the men and women in attendance. Members are urged to bring ladies and guests to this all-day meeting of the Section. A special program consisting of a sight-seeing trip, reception or cards is provided for the ladies during the day.

This planned program and the early announcement of it to the membership, as well as the publishing of the "S. P. E. E. News Bulletin" which contains up-to-the-minute news in regard to what is going on in the New England institutions, have had a large part in the increased interest shown by the members of the New England Section.

FINDING A COMMON DENOMINATOR

H. W. BIBBER, *Chairman, Ohio Section*

The Ohio State University

To "make sections wake up and live" it is necessary to *find a common denominator* of interest for the program of section and branch meetings. There are many possible factors for this denominator we found in Ohio this year as we prepared our program—many more than I would have expected. It is my purpose to give you an outline of some of the topics of common interest to a large proportion of our S. P. E. E. membership which we evolved, hoping others present may be helped by it. There are two main divisions of these topics, (I) those of current interest and (II) those of perennial interest. By current interest I refer to topics which arise because of recent events of a political, social, economic or scientific character. You will all know to what I refer by the title perennial interest.

I. *Current Interest*

A. Relating to educational methods and the instructional program.

1. National in scope

a. President Roosevelt's letter to engineering deans last autumn

b. Ideas on progressive education—projects—units of instruction—etc.

c. Depression's effect—on employment of grads—on curriculum content—NRA—NYA

d. E. C. P. D. accrediting—methods—significance—possible benefits

2. Regional in scope

a. T. V. A. in several southern states and its engineering implications

b. Financial situations in states and cities affecting institutions

c. Century of Progress Exhibition in Chicago for surrounding states

d. State's licensing of engineers

e. Labor troubles in industry as affecting teaching in colleges

B. Relating to the professional status of the teacher

1. Mostly regional in scope

a. Teacher's oath laws

b. Academic freedom in the state or at particular institutions

c. Limitations on outside consulting practice—by state law—by university itself—due to activities of professional engineers' societies

II. *Perennial Interest*

A. Pre-collegiate instruction and entrance requirements

B. Courses in the basic subjects: chemistry, physics, mathematics, arts of expression

C. Vocational guidance and academic counselling

D. The cultural content of engineering curricula

E. Applied educational psychology and examination methods

F. How technical service courses should be set up and taught

CORRELATION OF FUNDAMENTALS

W. S. RODMAN, *Chairman, Southeastern Section*
University of Virginia

For three years at its spring meetings this section has considered the correlation of fundamentals. One subject after another has been taken up and studied to see how it could best be fitted into the student's program to give it the proper emphasis and correlation.

MORE EFFECTIVE PRESENTATION OF PAPERS

R. NORRIS SHREVE, *Member, Illinois-Indiana Section*
Purdue University

There are two types of papers: the more formal ones, presented before the general sessions; and the more specialized ones, given at the various sections. These remarks apply to both kinds, but more particularly to those before the sections.

Judging from an experience of over ten years as an officer of technical societies, I have observed that those papers with the worst or most soporific effect on the audience are the ones where the author reads his presentation, with his eyes glued to his manuscript, including even the tables.

Hence my first rule would be: (1) to discourage greatly the *reading* of papers. This is particularly unnecessary where there is a predistribution of the full paper. My second rule would be: (2) To suggest to authors the use of lantern slides or wall charts for the presentation of data, particularly by means of curves rather than by columns of figures. As a corollary the reading of tabulated data should be absolutely prohibited. My third rule would be: (3) Not to allow long papers, the maximum time to be set by the officers. Much better results come from a short paper forcibly presented than from a long paper with its details of interest only to the specialist who should get his minutiae from the study of the printed paper. A corollary of this rule would be that more and shorter papers are greatly to be desired over a few long ones.

The *careless and tiresome* giving of technical papers is becoming an acute subject. Many openly state that they go to professional society meetings with the intention not of listening to the papers, but for the sole purpose of meeting their friends in the corridors. Others say, "Why listen to a long paper?—if it is worth while, it will be published, and I can read or glance through it then."

Other societies have drawn up "Suggestions to Speakers." Why cannot the S. P. E. E. do likewise? Certainly our society has sufficient strength and maturity to better its meetings by putting into the hands of *each* prospective speaker a printed impersonal set of suggestions.

Finally, the presiding officer of a section should keep his speakers to their allotted time—and not hurry the last men through their papers. This can be done diplomatically but firmly. To save some embarrassment, there are available devices that light a red lamp, two or five minutes before a set time, at which an alarm rings.

At this point, Mr. C. E. Davies, Secretary of the American Society of Mechanical Engineers, referred to a series of lectures by Dr. Tucker of The Brooklyn Polytechnic Institute on speaking before an audience. He referred also to a plan whereby Dale Carnegie would discuss methods of presentation and make suggestions to a speaker previous to his participation on a program.

Mr. Davies emphasized that each teacher is teaching class presentation every time he meets a class. The teacher must teach public speaking to the students in engineering.

If one must use tables or curves for reference purposes, Mr. Davies suggests strongly that these be in the form of good clear lantern slides. A bulletin sponsored by the A. S. M. E. and approved by the American Standards Association having the title American Recommended Practice in connection with "Engineering and Scientific Charts for Lantern Slides" may be obtained at a cost of fifty cents per copy by writing to the American Society of Mechanical Engineers, 39 West 39th Street, New York City.

THE RELATIVE ADVANTAGES OF TWO-DAY ANO ONE-DAY SECTION MEETINGS

G. P. BOOMSLITER, *Chairman, Allegheny Section*

West Virginia University

The advantages of the one-day session, particularly in closely knit sections are obvious, the main one being that class work will not be affected. If the session is held on Saturday and away from home expenses are reduced to a minimum. On the other hand, the two-day session seems to offer advantages, especially in far flung sections. If a day or more must be spent in travel to or from the host institution, involving the expense of several days away from home, the program should be made decidedly worth while. The

question which immediately arises is "What makes a program valuable and attractive?"

Obviously talks by prominent educators with a real message, informative or inspirational, are of first importance. Secondly, shop talks with fellows in one's own field are very important. These may occur in personal and private conversation or in departmental meetings with their discussion. Personal participation or the possibility of it attracts many. Forming new friendships or the strengthening of older ones is a motivating element in attendance. Inspection trips, either of the facilities of the host institution, of engineering works nearby, or of scenic or historic surroundings, decides many to attend meetings. The success of the present annual meeting is due to a happy combination of all of these elements. All of them are recognized in selecting convention cities by nearly all organizations.

At a recent meeting of the Pittsburgh branch of the American Society of Civil Engineers, Secretary Seabury in speaking of the advantages of society membership particularly stressed the social value of the meetings of that society in extending acquaintances or enjoying old ones.

The speaker wondered if a one-day meeting might not be too hurried, so that it might become a "hello-goodbye" session with few lasting impressions of contemporaries and with little opportunity for making acquaintances in one's field or of the sister institutions in one's section. Furthermore S. P. E. E., like other continuing organizations, needs a steady infusion of new blood. The departmental meetings of the second day are an instrumentality for bringing the younger men into active participation, but they often have college duties which keep them at home unless arrangements can be made for holding their classes. However, public schools declare a holiday when state or regional meetings of teachers organizations are held. Would it not be profitable for engineering institutions to do the same for sectional meetings of the S. P. E. E.?

In order to obtain the present practice in regard to length of session a questionnaire was sent to each of the 17 sections of the society. They were asked the number of institutions in the section, farthest distance between colleges, whether meetings were one- or two-day meetings, number in attendance, percentages from host institutions, whether interest was increasing or decreasing, etc.

It was felt that by reading between the lines some information might be obtained concerning the effect of the length of meeting on attendance and interest. Twelve sections responded and the information obtained from them is given. On the second sheet is a summary of the most interesting information.

SECTION MEETING PROCEDURE OF S.P.E.E.

Section	Year founded	No. Col. in Sec.	Far. dist. bet. Col.	Spr. or Fall meet.	1 or 2 da. meet.	No. in attend.	% from host inst.	Int.	1 or 2 da. meet. prefer.	Remarks
New England	1921	16	395	Fall	1	275	11%	Inc.	1	
Illinois Indiana	1935	7	200	Spr.	1	250	33⅓%	Inc.	1	
Kentucky	1926	2	90	Spr. and Fall	1	25–35	50–100%	No change	1	One annual meet. Alternate sch. each year.
S. E. Section	1934	29	1200	Spr.	2	50–35	45–33⅓%	—	2	School hard to get to
Missouri	1933	3	126	Spr.	Eve. and next A.M.	50	50%	Inc.	1½	
Ohio	1920	10	250	Spr.	1	65	⅓ to ½	Inc.	1	Meet at O. S. U. in alternate yrs. because of central location. Invite neighbors
Pacific Northwest	1932	7	1200	Spr.	2	50	30%	Inc.	2	Fri. eve. and Saturday
Arkansas Oklahoma	1930	3	250	Spr.	2	75	50%	Holding	2	Fri. eve. and Saturday
No. Midwest	1935	5	600	Fall	2	189	⅓ to ½	Inc.	2	
Middle Atlantic	1924	22	400	Spr. and Fall	1	160–375	25–75	Inc.	1	Spr. meet. in country. Fall meet. in city.
Pacific So. West	1930	9	1000	Xmas Week	3	75–100	25%	Inc.	2	Winter during Xmas Week
Allegheny	1935	5	250	Fall	2	125	30%	Inc.	2	
Minnesota	1936	3	40	Fall-Winter-Spring	3	40	95%	Inc.	?	All meet. at Univ. of Minn.
Kans.-Neb.	1936	3	225	Fall	2	—	—	—	2	
Texas	1930	9	700	Spr.	2	100	50	Holding	2	Rotate
Col. Wyom.	1933	6	200	Fall	1	30	?	Inc.	1	
Michigan	1936	5	140	Spr.	1	85	35	Inc.	1	

The distance between most distant schools in a section varies from 90 miles, a two-hour drive, to 1200 miles, a long 3-day drive; number of schools in a section from 2 to 29. The average percentage of attendance from the host institution was about 40 per cent. Eight had two-day meetings and seven had one-day meetings. (Kentucky has two annual meetings, one in the spring and one in the fall.) Attendance varied from 35 to 375. As twelve out of fifteen report interest as increasing it would seem that most sections have found the most satisfactory arrangement for their particular needs.

It will be noted that the far flung sections in general have two-day meetings while the more compact have a one-day meeting. Several sections have hit upon what may be a happy medium. They hold their first meeting on Friday night following a dinner and the second meeting is held Saturday morning, adjournment being at noon, on Saturday. This plan interferes but little with class work and yet allows some time for sociability and inspection trips. The Pacific Northwest section last year opened their meeting at noon Friday with an inspection trip and the formal program started with a dinner on Friday evening.

As a result of this questionnaire it would seem that the question of one or two day meetings depends upon the attitude of the administration concerning the importance of the meeting and the distance between institutions, but the idea of Friday evening and Saturday morning sessions is a compromise which is worthy of attention in many cases.

SUBSIDIZATION OF SECTIONS BY THE PARENT SOCIETY OR ITS COLLECTION OF SECTION DUES WITH THOSE OF ITS OWN

FRANKLIN O. ROSE, *Secretary-Treasurer, Pacific Southwest Section*

University of Southern California

The activities of the local sections form a very important part of the work of our organization. In the cases of a vast number of its members they are, for geographical reasons, their only personal contacts with the Society. The meetings of the sections compare very favorably with the annual meeting of the Society, as far as the benefits to be derived from attendance and participation are concerned.

In view of these facts, it would seem not unreasonable to suggest that some assistance in their financial affairs be given to the sections by the parent society.

It costs money to arrange for the regular meetings of the sections and, for that purpose, dues, over and above the national dues, have been levied upon the members within the geographical limits of the sections. In the Pacific Southwest Section these dues have been 50 cents a year and they have been collected by the Secretary-Treasurer from the members by correspondence. This has involved an expense on the part of the section for postage and some inconvenience for the individual members.

My suggestions are that either a stipulated amount, say 50 cents, be added to the national dues, collected by the Secretary of the Society with the national dues and turned over to each section in accordance with the number of members of the Society in that section's territory, or that the Society be asked to recognize the importance to it of the activities of the local sections to the extent of an out-and-out subsidy of a similar amount. Personally I would prefer the latter plan.

During the five years in which I have been Secretary-Treasurer of the Pacific Southwest Section, we have been able to collect, under the present arrangement, dues from sixty to seventy per cent of those members of the Society who should be members of the section. The foregoing is not in the nature of an attempt to lighten the duties of the local treasurers. It is rather an effort to aid the members and to increase the efficiency of the sections.

Dean Case here asked for discussion of methods of financing the expenses of the sections which appears to be a rather serious problem.

R. G. Paddock, University of Arkansas, spoke of a method of collecting funds from those attending section meetings.

Dean R. L. Spencer, University of Delaware, of the Middle Atlantic Section, spoke of a method of collecting $1.00 from each one present. In this section each one pays 75 cents for lunch and $1.00 for dinner. Also, Dean Spencer stated that the institution members were urged to bring to the section meetings their young instructors and introduce them. The program, which is supervised by the host institution, provides for an inspection trip in the morning and a technical session at 2:00 P.M. consisting of two papers and discussions. In the evening there is a lecture to which the ladies are invited. The officers—a chairman, vice-chairman and secretary-treasurer—are changed annually.

Dean Case then suggested that a study be made of the cost of operating the sections together with methods of financing this expense.

OPERATION OF A LOCAL SOCIETY, PART OF WHOSE MEMBERS BELONG TO THE S. P. E. E. GROUP

R. C. KINTNER, *Chairman, Bucknell Branch*

Bucknell University

We are a small institution insofar as number of engineering faculty and students are concerned. Many years ago a group of the engineering teachers felt the need of some organization at whose meetings certain things could be discussed. The promotion of group interests, social functions, new scientific developments, and other items formed the programs for the meetings. The group, being composed of the engineering teachers, was a very closely knit one with many things in common. This society was named the Technical Conference. The society has grown and expanded by bringing in first, the physics and mathematics teachers, then those from the chemistry department, and finally the biology department. At present its membership is composed of eleven engineering, seven natural sciences, and four biology teachers.

A few years ago we held meetings once a week but found that other meetings interfered too frequently. Now we hold two meetings per month when school is in session. These meetings are scheduled from 4:30 to 5:30 P.M. The attendance averages about fifty per cent for ordinary talks. The first meeting of the year is held about two or three weeks after the start of the fall semester. At this meeting, a time of meetings and the place is determined for the first semester. At the beginning of the second semester, these items are again voted upon. Also at the first meeting of the year, the report of our delegate to the national meeting is received. At subsequent meetings we have papers from the members, each taking his turn in alphabetical order. This makes about one paper per year per person. During the fall semester a social meeting is held to which the women are invited. Our members from our Junior College at Wilkes-Barre also come to this social meeting. A few guests are also invited. During the second semester a stag party is held at one of the mountain camps near Lewisburg. We have a picnic style of supper, preceded and followed by various forms of entertainment. The annual election of a Chairman and Secretary as well as the election of a delegate to the national meeting is taken care of at the end of the supper when everyone is feeling good. This is usually the final meeting of the year.

The society, by consent of the national group may act as a branch of the S. P. E. E. When voting is done, all members vote alike on the question, some of those not members of the S. P. E. E.

refraining from voting although there is no rule to that effect. By having the physics, mathematics, chemistry and biology people present, a wider and more liberal discussion is obtained. We joined the new Allegheny Section when it was formed and have had a large percentage representation at each of the Section meetings to date. The frequent meetings allow us to transact S. P. E. E. business promptly. The other scientific teachers on the campus get our engineering viewpoint on matters of importance. Since a large portion of their classes come from the engineering departments, they are glad to discuss such items as course content, individual students, changing of curriculum, applications of their field of science, etc., with the engineering teachers. At these meetings are instituted some of the Engineering Faculty Meetings, since we do not hold such meetings at regular intervals but only when there is important business to transact. To summarize, we make the Technical Conference serve whatever purpose we can and as many purposes as we can. When a visiting celebrity comes to our campus, it is the Technical Conference which usually initiates and carries through a luncheon or special meeting in his honor.

Our financial condition is always in excellent shape, as we have but very little expense. Correspondence is carried on using the college stationery, except for the announcements of meetings. This latter is a postal card upon which we stamp the time and place of meetings. The Secretary mails these each time to every member. The treasury is replenished by a painless extraction method at each of the social meetings. We simply charge the members seventy-five cents for a sixty-cent dinner or picnic supper and tell them we are doing it. We also fall heir to most left-over funds from other engineering social functions.

We are not without our troubles, however, chief among which is the low attendance at times. There have been meetings at which only four or five of the twenty-two have appeared. This was nearly always due to the interference of other functions. The writer has always felt that fewer meetings at more irregular intervals would have a better attendance record than regular meetings at more regular intervals. A regular time for a meeting places the stamp of duty upon the function, while irregular times of meeting, places them in the entertainment class. Some of the talks lack universal appeal to so varied a group and this makes for lack of interest. We have almost 100 per cent attendance at the two social functions each year.

We at Bucknell feel that the advantages outweigh the weak points and the organization will continue to function as a dual society.

Professor W. D. Garman, chairman for 1937–38, then emphasized that much greater interest is manifested if the meetings begin and end on time.

PRESENTATION OF COURSE CONTENT DISCUSSIONS AS SUBJECTS OF PAPERS IN BRANCH MEETINGS

F. W. SLANTZ, *Chairman, Lafayette Branch*

Lafayette College

Meetings should have an orderly sequence and a coherent program for the year. Of great help in maintaining interest is to give at the beginning of each meeting a brief outline of matters discussed in previous meetings.

Departments are often uninformed regarding the activities and problems of each other. By requesting selected members to speak on the aims of their respective departments there has developed a realization of the interdependence and the need for a mutual interest among departments.

Branch meeting discussions regarding matters of institutional interest have clarified much misunderstanding and been of great value in connection with the general faculty meetings. Also through discussions at these Branch meetings young instructors with novel ideas which they believed original often find that these ideas have already been tried and discarded.

A topic suggested for branch meetings is the question of which department shall teach Mechanics—the M.E., C.E., or Physics Department.

INTERDEPARTMENTAL COÖPERATION IN TEACHING OF COURSES

ROSCOE W. MORTON, *Chairman*

Colorado School of Mines Branch

At the Colorado School of Mines we have had what we think are excellent results in the interdepartmental coöperation in teaching several courses. Some time ago in reviewing the content of Mechanical and Petroleum Engineering Courses, the head of the Petroleum Engineering Department, and myself, found that in several concurrent senior courses we were both spending time reviewing more or less the same material as introductory foundation. It also appeared that a combination of the several courses into a

single course with a combined teaching staff might prove profitable in saving time and repetition and permit of class coördination of the subject matter. At the time of this study the courses in question were for some reason or other titled: "Compressed Air," "Pumping Machinery" in the M.E. Department and "Gas Meters and Gas Lines," "Oil Lines" in the P.E. Department. The time was 7 class hours and one 3-hour laboratory per week.

Upon a comparison of class notes and assignments we found that certain duplication of material could be omitted, reducing the time to 5 days per week plus the 3-hour laboratory period, and yet we could strengthen the whole work by close correlation in some additional long problems.

The course entitled "Fluid Transfer" now covers in six chapters, "Meters, Pumps, and Pipe Lines" for liquids, and "Meters, Compression and Compression Machinery and Pipe Lines" for gases. In the laboratory period we have the experiments on some of the various pieces of equipment discussed in the lectures. The work is divided between Professor Boatright and myself in the class periods and during each chapter the one in charge uses the 5 class hours. Both of us work the laboratory. The administration is coöperative as is the grading compilation. Fortunately we have only one section of this course and so it is not too difficult to make our schedules.

The principal advantage that I see in an arrangement of this kind outside of the time saved is in the requirement of the student to correlate his previous fundamentals with the applications at hand as presented by the two departments in the same course. He can no longer say, "But, Professor, that is in a different course." What's good for the goose is also good for the gander so we on the faculty also benefit in our preparation and execution of the work by constructive scrutiny of each other.

There are several other coöperatives now working or in the planning stage.

This mutual perusal of course content in more or less detail led to a series of meetings of our branch in which we asked members of the staff of the various departments to discuss items of the various fundamental or preparatory courses that were the main backbone on which the advanced work was built. We have found that this discussion has brought out that a little change here or there or maybe just a change of emphasis has brought about closer correlation among related subject matter. In this way the graduating departments can also point out some of the trends or changes taking place in their specific fields and thus aid others in an attempt to be conscious of these trends. It is my belief that this cooperation is healthy to all concerned.

REPORT OF NEWARK BRANCH MEETINGS

ALBERT A. NIMS, *Representative,*
Newark College of Engineering Branch

The following are topics presented before this Branch. These may serve as suggestions for other Branches.

At the instigation of a staff member taking advanced work at Columbia papers were presented on:

1. Improving the Study Habits of Students.
2. The Problem Method in an Engineering School.
3. Laboratory Instruction.
4. Classroom Discipline.
5. Retention of Learning.
6. At the final meeting of the year R. H. Morrison, State Supervisor of Colleges, reported the results of an inspection of colleges in New Jersey. He mentioned the common complaints of student bodies.

A LUNCHEON MEETING AS A MEANS OF REVIVING INTEREST IN THE LOCAL S. P. E. E.

W. S. EVANS, *Representative,*
University of Maine Branch

I think I am correct in saying that a few years back the University of Maine had one of the most active branches of the S. P. E. E. During those years we discussed and argued such questions as how best to raise standards, the best time for introducing laboratory work, methods of teaching, comprehensive examinations and similar subjects. It is not easy, however, to maintain interest over a long period of time. Certain ideas are pushed across and then we sit back and wait for results. We have just been through one of these waiting periods.

After a lull, it is not easy to arouse enthusiasm over just another meeting or society. With a program already crowded with technical society meetings, research groups, seminars, and special features, if more than the chairman, the secretary, one department head and two instructors are present, the occasion warrants the expression of joy. In a small institution such as the University of Maine one knows how his brother faculty member feels about any problem and hence one does not attend society meetings to get his fellow associate's ideas upon the announced subject but rather to satisfy a sense of loyalty to him. This sense of loyalty is not always as strong as it should be either.

It is a fine thing for a group like this to meet, exchange ideas and discuss varied topics of mutual interest. The section meetings are also a worth-while work of the Society and I enjoy them as much if not more than I do the national meetings. But if, as indicated before, there are no ideas to exchange in a small faculty group, is it worth while to hold monthly or quarterly branch meetings? That is the question which it was felt that we at the University of Maine had to answer for ourselves.

Other groups on the campus had held luncheon meetings with some success. We tried one with no program except to see what should be done about regular meetings. Probably two thirds of the Technology Faculty were present. There seemed to be no doubt that monthly meetings to discuss current topics and problems were very much worth while if a program could be arranged which would draw out a good group of faculty members. It was felt that to get together once a month for a good lunch and to swap experiences at the table was worth while, even without a definite pre-announced program. I happen to be a member of one club which arranges a program of hosts and speakers for a year in advance and our meetings are the most enjoyed of any meetings of which I know. I wanted to see the Maine Branch of the S. P. E. E. organized on a similar plan but it wasn't quite. Instead of drafting speakers, volunteers were asked for and members enough signified their willingness to present papers or to lead discussions so that programs for the next year are assured. Two meetings have been held since the organization meeting and both have been well attended. On those occasions we have announced the subject for the meeting, but I am inclined to think that it is better not to. It might be well to announce neither the speaker nor his subject.

I know I have said very little and nothing new. I have called your attention to the idea that on a full stomach and behind a good pipe or cigar, faculty members, like other human beings, listen more attentively and react more favorably than in any other state of being. For the coming year we are looking forward to a full program of meetings with full stomachs and a good attendance at least once a month.

In closing the meeting Dean Case suggested that a questionnaire be circulated to obtain information regarding the operation of the sections and branches. He referred to a knowledge of the date of the election of officers together with a list of the new personnel as being of extreme importance.

L. W. Hitchcock,
Secretary.

FUNCTION OF AN ENGINEERING TEACHER

By RUSSELL C. BRINKER

University of Hawaii

To at least one of the younger faculty members some question has arisen as to the function of an engineering teacher. Presumably, as the title implies, the attendant duties should consist of instructing students in the principles of engineering. In the light of recent papers and discussions, however, especially some of those presented at the S. P. E. E. meeting in Atlanta in 1935, other factors appear to be overshadowing teaching interest and ability as requisites for faculty appointment and promotion.

These factors, namely research, publications, and advanced degrees, might all be classed under the single term, "productive scholarship." Perhaps use of this term is unwise because of a possible implication that conscientiously teaching students is not productive scholarship. If the original coiner of the term had that in mind, the text of this paper is predicated upon the opposite viewpoint.

The most illuminating comment on the effect of productive scholarship upon the more prosaic, routine, and implied duties of teaching was contained in an answer to the Society's questionnaire on Freshman Orientation, which read as follows: "Men who can satisfy all the requirements for an effective counselor and who are willing to serve in that capacity are not plentiful. Capable and ambitious men are reluctant to assume the responsibilities and the hard work that are connected with counselling, however much they may be interested in such a program, because they fear that recognition and promotion may pass them by. This is a consequence of the emphasis which is given to productive scholarship, meaning research, publications, and advanced degrees, in determining an instructor's eligibility for promotion." *

Without entering into the merits or desirability of Freshman Orientation, truly it is a sad state of affairs when a teacher cannot find time for student counselling. Honest recognition of the situation as in the case of the school giving the quoted answer, should lead to some reforms in present administrational policies with regard to faculty promotions.

Denial of the value of the three elements of productive scholar-

* *Journal of S. P. E. E.*, October, 1935, page 1128.

ship could only indicate ignorance of the knowledge upon which engineering has been built. They have their place. But for the full time teacher they should be secondary considerations, not primary. It is the purpose of this paper to present the viewpoint of the lower ranking men who are most effected by this modern trend of education.

Some schools are now demanding that their staff members indulge in research, whether or not their desires and inclinations are in that direction. Would such schools also have their students take an engineering course although they preferred, and were more capable in, a different field? Or have their engineering graduates enter pure research when obviously they were the engineering salesman type?

Research usually is exacting in its time requirements. A man carrying a full teaching load and attempting serious research may expect sooner or later to find the demands of one interfering with the other. If research minded, he neglects class preparation. If not, the research suffers. In neither case does a satisfactory situation ensue. It should be recognized that where a conflict occurs, the tendency will be to favor research, for (1) A check on the research results can be obtained easier than upon teaching accomplishments, and publicity follows the same route, and (2) The possibility of discovering new facts is more interesting than repeating the old ones of many years teaching. Furthermore, research will not make a man a good teacher—on the contrary, it will probably confine his time, interests, and reading to one perhaps isolated portion of his own field, to the exclusion of even the courses he may be teaching.

The solution appears evident, but financially difficult to carry out. Discard the research requirements for all staff members (either specified directly or understood to be necessary for promotion), and appoint men to full time research positions, or lighten the teaching schedules to permit concentrated periods of laboratory work. Some publicity and half-hearted research may be lost to schools if funds are not available to follow this policy, but better graduates and a lower student mortality will result. It might be noted that (1) Research at small schools often involves expense (for apparatus, materials, and assistance) to individuals not on large salaries since the school cannot provide funds, and often the resultant equipment will be unsatisfactory. (2) Men in attics will still discover startling new facts, but for deep fundamental research, a knowledge of chemistry, physics, mathematics, civil, electrical, and mechanical engineering is necessary, and except in rare cases, can only be furnished by the coördinated staff of a large company engaged in research backed by sufficient capital.

At some schools publications form the basis for promotion. One civil engineering department, for example, appears to consider publication of a textbook a prerequisite for advancement to the higher professorial ranks. The value of manuscripts may be incidental to the number of pages. Thus a year's important research may be condensed into relatively few pages and suffer on abstract office records when compared to less valuable stretched-out papers. The inevitable result is the publication of things perhaps better said previously.

The same comments pertinent to research apply to publications. If a staff member must publish for promotion, he will soon feel justified in neglecting class preparation. After all, it is difficult to balance conscientious grading of endless problems and reports against the satisfaction, vanity, and monetary return resulting from seeing one's name appearing frequently in the technical magazines. Perhaps the higher ranking men have schedules light enough to permit indulgence in the publication fever, but it is the young man, ordinarily more heavily burdened with classes and paper grading, who must produce.

One type of "unpublicized" publication that personal contact with many teachers and classes indicates could be profitably used, is a short set of mimeographed sheets covering the more complicated drawings and sketches discussed in lectures. It is excusably difficult for a student to try to copy a sketch from the blackboard, and at the same time get the trend of the lecture. Divided attention results and is fatal. A suggestion therefore would be to turn some of the publication energy into preparing notes and drawings of the more difficult features and problems not covered in the course textbook, and thus permit the student to follow the lecture secure in the knowledge he had a well drawn diagram for later reference. Also, spend publication time in the preparation and correction of examination questions designed not to elicit a parrot-like list of facts and figures, but to require the use of judgment in stating how selected practical problems would be tackled in the field and office.

Figures gathered by the Society indicate many more doctorates in engineering have been given during the past few depression years than in previous periods of similar length. In appointing teachers, therefore, it is natural that a larger percentage should have this advanced degree. One university has gone a step farther, however, and put into effect an arbitrary rule stating that every instructor (in all departments except physical education, military tactics, and teachers training school) must obtain a Ph.D. or the equivalent within the next five years to hold a position. The doctorate cannot be obtained at this institution in engineering, or in any field except agriculture, and no provision is made for getting

it except the granting of leaves, hence the instructors face the problem of financing several years of graduate study elsewhere. Presumably future appointments would be given only to men having the doctorate or willing to follow the throng. Thus is repeated the principle of employing and advancing teachers on something other than teaching ability.

Like research and publications, the doctorate has its place. But unless graduate courses leading to this degree are to be given, a Master's or earned professional degree, plus the two extra years spent in practical work instead of in courses for a doctorate would seem preferable. In relatively few schools is this highest of degrees given. Certainly the teaching value of a doctorate (probably in structures or hydraulics) to a man instructing classes in drawing, surveying, highways, and railroads appears small indeed. If the doctorate in engineering is to become commonplace, then the Master's degree will mean little more than an undergraduate fifth year, and will be awarded for such meritorious theses as one entitled "Four Ways To Wash Dishes" which recently was accepted in the Home Economics Department of a progressive university.

In practice a man must produce or fall behind. In teaching the same should be true, with students comprising the main product, and other items being classed as by-products. If productive scholarship is to become a necessary evil, papers, research, and degrees will be ground out. But the by-products will precede the main product in importance.

The opinions expressed in this paper will probably fall heir to criticism by many. Discussions with teachers of high and low rank indicate, however, that thoughts collected herein are fairly general. One professor said his mistake has been failure to "steal" time from his duties to publish. Yet despite his pronounced lack of advanced degrees, publications, and research (according to the present day stupendous totals of some men), graduates consider him one of the best teachers they had. His time was free for questions, and papers were marked carefully to point out errors and leave no doubt as to where one stood. Similar examples are available on all sides, and appear to far outnumber those outstanding teachers who might be picked from the productive scholarship group. Routine duties combined with the task of keeping up with five or more technical magazines leave little time free if class notes are to be revised and improved, and some contact kept with non-engineering fields and interests. A study of class schedules, hours required for preparation and conferences, and time needed for some social life and reading, of teachers at different institutions would undoubtedly show few spare moments left for indulgence in a hobby.

It is believed that a questionnaire, perhaps similar to that sent out by the Society to obtain data on Freshman Orientation, would make available valuable information concerning administration policies relative to the points discussed in this paper. Presentation of results might be made through the JOURNAL of the Society, or at a future convention where discussions of vital interest to both administrators and staffs could be given.

A NEW DEPARTMENT OF MECHANICS

By ARTHUR S. ADAMS

Professor of Mechanics, Colorado School of Mines

In 1928 the writer became interested in the possibilities of correlation between the subjects of mechanics, hydraulics and thermodynamics. At that time, in the Colorado School of Mines, as in many other institutions, analytic mechanics and hydraulics were taught in the Civil Engineering Department and thermodynamics in the Mechanical Engineering Department. However, the three subjects actually constitute the mechanics of solids, liquids and gases. Certainly no one would contemplate teaching the chemistry of solids, liquids and gases in different departments, nor would they be taught simply as accessory courses. The writer felt that it was equally important to unify and correlate the instruction in mechanics by creating a single department in which these subjects would be taught.

Many discussions with the administration took place during the winter of 1929 concerning the matter. The curricula of numerous institutions similar to the School of Mines were examined to see whether the idea had been tried before. It was found that something along the same line had been used at Stevens Institute of Technology and at Washington University at St. Louis. It was finally decided early in 1930 to organize a Department of Mechanics which would have charge of the instruction in the three branches mentioned. A few months later Professor William Hovgaard of the Massachusetts Institute of Technology published an article * which had for its thesis the desirability of a reform in the presentation of theoretical mechanics in engineering schools. This excellent article gave added impetus to the writer's enthusiasm for the projected department. The department began functioning in the fall of 1930 and it seems proper at this time to describe what has been done, as well as the methods of its accomplishment.

In Professor Hovgaard's article cited above, the science of theoretical mechanics is divided into four sections: Mechanics of a Particle and of Rigid Bodies, Mechanics of Elastic Bodies, Mechanics of Fluids including hydrodynamics and aerodynamics, and Mechanics of Gases. The curriculum at the Colorado School of

* *Science*, April 4, 1930, 347–350.

Mines does not permit the exhaustive treatment suggested by these subdivisions, hence it became necessary to plan the work on the basis of introductory courses in analytic mechanics, elementary hydraulics and elementary thermodynamics. Great difficulties were experienced and still are being encountered in the matter of the selection of suitable text books. Apparently the three subjects mentioned have been taught so long as separate entities that the possibility of correlation between them is seldom recognized by text book authors. However, by making out specific assignment sheets which make reference to sections of the particular text book dealing with the topic in hand, it has been possible to make satisfactory progress.

Since improved correlation was the entire objective of the new department, great stress has been laid upon it. The detailed outline of the several courses shows how this has been accomplished. The work of the department begins with students in the second semester of the sophomore year. The first course in the department meets five days a week and has for its immediate objective a thorough training in the elementary mechanics of solids and liquids, i.e., analytic mechanics and hydraulics. Prerequisite to the course is a first course in college physics and courses in mathematics through differential calculus. After the general principles of equilibrium of a particle and of rigid bodies have been studied, their application is extended to problems in hydrostatics. This procedure immediately results in widening the student's perspective of the laws of equilibrium, in that he sees that their application is not limited solely to the determination of stresses in bridges, trusses and the like.

After completion of the study of the laws of equilibrium the student then undertakes the study of kinematics and kinetics of a particle and of rigid bodies. The conventional presentation is followed here until the study of work and energy is reached. This topic is given extended treatment which has its climax in the development of Bernoulli's equation. Great stress is laid upon this development and its applications in order to insure a clear and logical connection between the mechanics of solids and of liquids. The remainder of the first course is devoted to the application of the Bernoulli equation to problems of hydrokinetics. The work of the entire course is planned to be completed in 80 lectures.

Thermodynamics, the second course in the Department of Mechanics, is given on a schedule of three lectures per week in the first semester of the junior year. Prerequisite to the course are courses in physics and mathematics, through integral calculus, as well as the first course in mechanics described above. The Bernoulli

equation, generalized to express the First Law of thermodynamics, supplies the correlation link between the first and the second course. After some introductory definitions and history of the subject, both the First and Second Laws of Thermodynamics are carefully developed as energy principles, without regard to the nature of the media employed. The writer's experience has been that this particular presentation is vital to the success of a first course in engineering thermodynamics. Even with this stress on the first and second laws as energy principles, examinations all too frequently reveal that the student regards the Carnot cycle as somehow indissolubly connected with the notion of a perfect gas. Moreover, it has also been observed that if the study of thermodynamics is begun by consideration of the perfect gas laws, the student gets the idea, which is nothing short of maddening to the instructor, that the perfect gas laws will solve all thermodynamic problems.

With the fundamental ideas of the first and second laws in mind, the student then proceeds to the study of the generalized principles which may be deduced from them. The topics considered are general thermodynamic equations, the Joule-Thompson effect, the Clapeyron equation, maximum work, free energy, and the Gibbs-Helmholtz equation. The general principles thus established are then applied to the determination of energy changes for gases and vapors. The last part of the course is devoted to consideration of both media in practical cycles, such as the Otto, Diesel, air compression, and Rankine cycles. The course in thermodynamics is planned to be completed in 54 lectures.

Throughout both courses considerable attention is given to the concept of dimensional analysis. For each relationship established, both the nature and significance of the dimensions involved are carefully presented. The writer has observed that when the merest beginnings of dimensional analysis are given, the student quickly sees the value of the idea and from then on exercises considerable initiative in further developing his concept of the significance of dimensions.

The work of the Department of Mechanics also includes the teaching of advanced courses in vector analysis, theoretical mechanics, hydraulics and thermodynamics. All of these courses are elective for most of the students taking them. It is gratifying to note the number of students who have been interested in continuing their work beyond the required elementary courses.

The essence of this article is to invite attention to the possibilities of correlation between the several component parts of the science of mechanics. The importance of this science as the foundation science for all engineering cannot be questioned. Separate

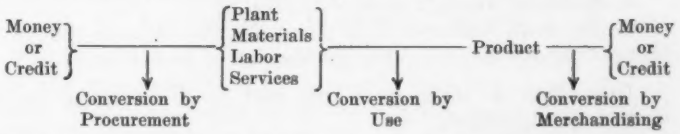
courses, taught in separate departments, can never give the student the broad and correlated comprehension of the underlying principles of mechanics that he must have to be a successful engineer. The experience of the past seven years convinces the writer that much can be done towards achieving this correlation when all phases of mechanics are taught in a single department.

ECONOMICS AND INDUSTRIAL MANAGEMENT AS SERVICE COURSES IN ENGINEERING *

By PROFESSOR C. E. BULLINGER

The Pennsylvania State College

Professor Rautenstrauch of Columbia University has suggested that the economic cycle may be diagrammed as follows:



If the phrases below the diagram are examined and compared with engineering practice, it will be seen that the engineer is vitally interested in each one of them. His position with reference to each of these phases is as follows:

Conversion by Procurement	Conversion by Use	Conversion by Merchandising
The Engineer as a Buyer	The Engineer as a Producer	The Engineer as a Seller

There are, therefore three phases of the economic cycle in which the engineer is interested:

1. As a Buyer, in the Economics of Exchange or the study of the Price Structure.
2. As a Producer, in the Economics of Production or the study of Costs of Production.
3. As a Seller, in the Economics of Purchasing Power or the study of the Distribution of Wealth.

It is generally assumed that a course in traditional general economics will provide the student with a foundation for the above three phases of the economic cycle. This view is quite frequently disputed, since one hears continually the lament that the engineer after having been exposed to such a course still does not know what it is all about.

* Presented at the Allegheny Section meeting of the S. P. E. E. at Morgantown, W. Va., West Virginia University, Oct. 23 ,1937.

At recent conferences on the teaching of economics to engineers the following remarks have been heard:

1. The engineering student does not like abstract mental disciplines.
2. He wants to see principles applied to practical programs.
3. He wants to see the relationship between theory and reality.
4. He is interested in seeing things work.
5. He wants to know if it can be applied.
6. The best teacher is one who will talk in the language of the student of engineering.
7. The illustrative material must suit the student's field.
8. Economic analysis requires maturity.
9. The traditional course in economics confuses the student by introducing too many speculative theories of economics.

How, then, is training in this field to be provided for the student of engineering?

May I suggest four service courses as a solution of this problem and indicate their characteristics.

They are:

1. Economic Law.
2. Engineering Economy.
3. Economic Philosophy.
4. Industrial Management.

Economic Law

I believe that most of the confusion concerning economics which is evident in conversations, the daily press and even in the minds of educated people arises because when originally taught there was a mixture of economic law and speculative theories concerning the actions of human beings towards economic law.

The law of supply and demand is the basis of all economics. "In simple language it means that an *increase* in the *demand* for any commodity *increases* its value in relation to other commodities; and an *increase* in the *supply* of any commodity *decreases* its value in relation to other commodities." (Mooney.)

I believe that a simple explanation of the various economic factors and economic situations based on this law but without introducing speculative theories will reduce the confusion that now exists.

This course should be designed to take care of the first and third phases of the economic cycle which are really, complementary, namely, the economics of exchange and the economics of purchasing power.

The major topics in this course should be:

A. The Law of Supply and Demand.
B. The Medium of Exchange.
C. Gold.
D. Currency and Credit.
E. Gold and Paper.
F. The Gold Standard.
G. The Debt Structure.
H. Prices.
I. Price Equilibrium.
J. Foreign Trade.
K. Purchasing Trade.
L. The Farmer's Purchasing Capacity.

The text material to be used in this course should be adapted from the ideas expressed by James D. Mooney, of the General Motors Export Company, in his book called the "New Capitalism." I particularly refer to his use of a hydraulic analogy (buoyancy) as a means of explaining graphically how the law of supply and demand works.

The objective of this course is to explain and illustrate how economic law works. It is to be done in such a way and with such materials as will attract the attention, curiosity and interest of the student of engineering. It will accomplish this aim because it will be presented in his language. No attempt is to be made to explain why different people place different values on the same thing or service.

Engineering Economy

This course should be designed to take care of the second phase of the economic cycle, namely, the economics of production.

The fundamental problem of engineering economics is the problem of investment, and may be stated thus:

Given two or more opportunities for the employment of capital, to determine which is the most desirable. (Fish.)

We are confronted with the problem of determining what combinations of goods and services will yield us the greatest amount of satisfaction. (Myers.)

Will it pay? (Grant.)

The engineer will recognize as particular forms of the foregoing problem of investment the following:

1. To choose between two structures proposed for a specified service.
2. To choose between two proposed ways of operating a given structure to produce a specified service.

3. To determine which of two proposed ways of operating a given structure will result in the greater net profit. (Fish.)

The major topics of this course should be:

A. First cost and operating cost.
B. Income, return and yield.
C. Intangibles or judgment factors.
D. Valuation and estimating.
E. Elements of statistics.
F. Methods of analysis.
  a. Break-even.
  b. Minimum cost.
  c. Alternatives.
G. Increment costs and sunk costs.
H. Load factor and the economics of capacity.
I. Replacement of machines.
J. Business units.
K. Financing business units.
L. Elements of Accounting.
M. Balance Sheets and Profit and Loss Statements.
N. The uses of compound interest.

The text material for this course to be adapted from the ideas of Fish in his book "Engineering Economics," Grant in his book "Principles of Engineering Economy" and Eidman in his book "Economic Control of Engineering and Manufacture."

The object of the course is to explain and illustrate how the various factors of production are combined and the results which may be obtained from various combinations of the same. It should be taught to develop the technique of an economy study and of a financial study rather than attempt widespread application in the various fields of engineering.

Economic Philosophy

Economic philosophy has to do with the ideas and theories which man has advanced to explain the workings of human society. It has to do with those intangible factors attributed to man which affect the workings of economic law. It discusses the effect of the actions of man upon economic law as well as the effect of economic law upon man's actions.

The major topics of this course should be:

A. Various approaches to the study of economics

Historical	Analytical	Statistical
Equilibrium	Eclectic	Institutional.

B. Ways of satisfying human needs and wants
Capitalism Socialism Coöperative
Communism Fascism
Other economic systems.

C. What is an economic system?

D. The various theories which have been developed to explain man's economic actions.

E. The various theories and hypotheses concerning the relationship of the factors in economic life.

F. The effects of government on economics.

G. The relationship of ethics, morals and religion to man's economic actions.

H. Contemporary economic problems.

The text material for this course to be adapted from the writings on the subject which may be found in text-books, journals, periodicals, magazines, the daily newspapers, reports of studies and other sources.

The object of the course is to explain the attempts of man to design an economic system and make it work according to the particular philosophy of life that is then in vogue. It should show what happens when man tries to set aside economic law and should make plain what may happen when economic law is ignored.

Industrial Management

This course should be designed to provide the technique which is needed by the engineer in the production phase of the economic cycle. It should provide for the technique of administration, management and organization of the productive process. This technique may be considered to consist of three sequences of topics coordinated by a fourth sequence of topics.

A. Methods Sequence.
A sequence of topics dealing with the methods of manufacturing including the engineering of tools, the design of jigs and fixtures, motion and time study, and factory planning.

B. Cost Control Sequences.
A sequence of topics dealing with the financial control of an enterprise, including work in accounting, cost accounting, budgetary control and standard costs.

C. Personnel Sequence.
A sequence of topics dealing with the mechanics of hiring, training, safety, industrial health, etc., psychology, as well

as the problem of the executive in his individual relations with his employees.

D. Organization Sequence.

A sequence of topics dealing with the history of scientific management and the technique of coordination of methods, cost control and personnel.

The text material for this course should be adapted from the writings on organization and administration of industrial enterprises. It should be presented from two view-points. The first presentation should be from a functional view-point. It is especially helpful to present the functions in the order in which they are used starting with the design of a product. The second presentation should cut across the functions and should bring out the fact that certain laws of management apply to all functions. It is best done by utilizing Emerson's twelve principles of efficiency as modified by Shepard.

The objective of this course is to explain and illustrate how an enterprise is administered, managed and organized.

CIVIL ENGINEERING DIVISION

HAROLD C. BIRD, *Chairman* — PAUL P. RICE, *Secretary*
H. E. BABBITT — HALE SUTHERLAND
F. T. MAVIS — H. T. HEALD

REPORT OF ACTIVITIES SINCE THE ANNUAL MEETING

HAROLD C. BIRD, *Chairman*

The first issue of the third volume of the *Civil Engineering Bulletin* was published the middle of December, and was mailed to the members of the Division and other teachers interested. Before mailing the *Bulletin* it was necessary to revise the mailing list. It was found that many on the old list have changed their locations, but it was very difficult to find their new addresses. If you did not receive your copy of the *Bulletin*, the Chairman will appreciate it if you will advise him of your correct address, and a copy will be sent.

The personnel of most of the standard committees is now complete and will be found on page ten of the December *Bulletin*. The members have felt honored by being asked to serve on the committees, and all the Chairmen are very enthusiastic. Each member of the Executive Committee is connected with one or more committees in the capacity of Contact Member to give advice and to be of such assistance as may be necessary.

Several of the committees have adopted a very definite program for the year's work, with one of the members acting as sub-chairman of each project. In some cases other members of the Division—not on the committee—have been asked to coöperate with the sub-committees for the year, serving as associate members of the committee. This will bring these members in closer contact with the work of the Division and from their rank the Division will find future officers and committeemen.

In order that the work of the various committees may be progressive and continuous, each committee will make recommendations as to the outline of the work to be followed in the following year. This, coupled with the fact that the personnel of each committee has a fixed system of rotation,* should make for increased efficiency in our committee work so that in a short time the recommendations of our various committees will carry a great deal of weight in the civil engineering teaching world.

* *Journal*, October, 1936.

ENGINEERING ECONOMY PAGE

Engineering Economy deals with comparisons between technical alternatives in which the differences between the alternatives are expressed as far as practicable in money terms.

EDMUND D. AYRES, University of Wisconsin, *Editor*

WHAT IS ENGINEERING ECONOMY?

Professors Ayres and Grant have given their definitions of engineering economy on this page in the issues of September, November and December, 1937. Professor Ayres would include practically every economic and social problem with which industry is concerned, while Professor Grant would restrict the field to "comparisons between technical alternatives in which the differences between the alternatives are expressed as far as possible in money terms."

My most fervent desire is to have engineering education include every one of the subjects mentioned by Professor Ayres in his two statements, provided this can be done, as I think it can, without weakening the technical engineering fundamentals. I must, however, protest vigorously against including all of these subjects under the name "engineering economy." Professor Grant has shown that the name "engineering economy" was first suggested by the late Professor Swain for the very purpose of eliminating the confusion which arises when any name means too many things. Many persons believe that one of the greatest obstacles we face in discussing subjects of this sort is caused by our inability in many cases to delimit them. Surely we should not allow ourselves to suffer needlessly from such a difficulty in the case of engineering economy which can be defined so clearly and so strictly if we only care to do so.

In limiting the use of the name "engineering economy" according to Professor Grant's definition we still have a very large and very important field which is not covered satisfactorily by any other name. The subject is just as definite as any of the technical subjects. Fundamentally there is as much difference between engineering economy and cost accounting as there is between thermodynamics and electrodynamics. Cost accounting is no more subordinate to engineering economy than mathematics is to mechanics. Mathematics is used in mechanics and in many other subjects. Accounting information is often used in engineering economy studies but it is also used for many other and different purposes. If we must have a single name for the broad field referred to by Professor Ayres, let us find a name which has not already been used so successfully to define a single very definite and very important part.

PAUL T. NORTON, JR.,
Virginia Polytechnic Institute.

ENGLISH NOTES

DEVOTED TO THE INTERESTS OF TEACHERS
OF ENGLISH IN ENGINEERING SCHOOLS

J. L. VAUGHAN, *Editor*

AN ATTEMPT TO TEACH REPORT WRITING WITH TECHNICAL PERIODICALS

As a project in report writing, upper-class students of engineering in a course in technical composition at the University of Maine have been required for several years to write a formal report upon a technical periodical. This report, which is of the nature of a survey, or examination, report, is in effect a complete and systematic review of the periodical.

Because the report is critical, as well as descriptive—a survey report with conclusions—the project encourages the discriminating reading of technical periodicals somewhat as does the course in advanced oral composition at the General Motors Institute which is described by Professor C. A. Brown in the issue of the JOURNAL of last October.

Primarily, however, the report is an exercise in report writing. The student attempts to present in accord with the principles of formal report writing all the significant facts concerning a technical periodical concisely, clearly, and accurately, with particular attention to the mechanics of form. For example, in order to make conveniently accessible to the reader any portion of the subject matter, the student presents the facts in logical self-contained units and sub-units under appropriate headings which appear in the table of contents of the report. He also finds opportunity to use footnotes, tabulations, extended quotations, and illustrative matter. Similarly, for practice in the preparation of the usual supplementary graphical and statistical matter, the student is required to supply two appendices. One is a bar-graph showing the distribution of the contents of the periodical by type—articles, departments, miscellaneous, and advertising. The other appendix is usually a statistical study of the distribution by type of the advertising matter.

Outlines are supplied the students for the report, together with detailed instructions as to form and content. Usually a period of

four or five weeks is devoted to its writing, the finished product, including the title page, letter of transmittal, and appendices, averaging over twenty pages of double-spaced manuscript. At the beginning of the report, the principles involved are discussed, and certain units of the report are submitted to the instructor for criticism and afterwards revised by the student. For example, the general description of the periodical, which sets forth its purpose and scope, the publication facts, the format, and the organization and arrangement, is submitted as one assignment. Of the sectional unit on the articles, one of several detailed reviews of significant articles is submitted for criticism. About half of the report is so submitted, the rest, including the general summary and conclusions, being done by the student without assistance.

Although much in the writing of the report is prescribed, opportunity for initiative and judgment is allowed in the proper proportioning of the several sections, in the discrimination shown in the selection of details, in the adaptation of specifications, and, especially, in the intelligence shown in the critical comment.

The report described above is not greatly dissimilar in many particulars to a survey report upon an industrial establishment. As such, it does give opportunity for more initiative and latitude in the application of the principles of report writing than does a routine laboratory report. It also avoids the too close adherence to the letter, as well as the spirit, that tends to be displayed in reports the material for which is garnered in a library. Until the ideal method of report writing in which the student gathers original data under the guidance of his technical instructor and prepares his report under the direction of a competent English instructor is generally possible, this report may be found a useful substitute.

W. F. Scamman,
Assistant Professor of English,
University of Maine.

The T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE DIVISION OF ENGINEERING DRAWING

FRED W. SLANTZ, EDITOR

DRAWING INSTRUMENTS, PAST AND PRESENT

Since the earliest recorded history man has been a builder and in order to bring his plans into tangible form it was necessary for him to develop a method of expressing his thoughts.

As the attempts of the early builders were crude so were the instruments which he used. History records that Ancient Egyptian papyrus maps, still preserved, were perhaps the first form of engineering drawing. There is no record of the tools these ancient artisans used, but it is known that at very early periods wood, copper, iron and even dry hide were used to fashion crude instruments.

Perhaps the most significant advancement in the art occurred toward the end of the twelfth century when the great religious establishments sent forth studious men to direct both monastic and secular works. A great period of construction ensued as men banded together into groups of artisans or guilds. The liberation of the arts and sciences from the monastaries gave impetus to the development of methods and tools for the artisans.

Records indicate that the chief tools of the Mediaeval architect consisted of a large wooden compass and a square. About 1700, however, the need of more precise ways of expressing ideas for reproduction became imperative.

The work of Watt, Stephenson, Bessemer and other inventive engineers stimulated the need for better tools, and early in the eighteenth century drawing instruments began to appear in greater variety and to assume a definite form. The craftsmen of Central Europe made most progress in developing instruments fashioned of iron and brass which enabled the architect and engineer to more rapidly express his ideas on paper. These instruments were hand forged and roughly shaped and, no doubt, often failed to function, but they were the forerunners of the modern precision instrument of to-day.

With the advancement in the refinement of metals about the middle of the nineteenth century craftsmen paid more and more attention to refinement of design. It was during this period that Theo. Altenader, a craftsman of the highest order, came to this country where he might work out his conviction that instruments should be so designed that they would respond to the will of the user without visible effort, in fact, become a *part* of the draftsman himself. Despite this high standard it was only through a period of difficulties and even hardship that the industry was finally established in this country.

In a subsequent issue we shall qualify the use of the word, "Precision" in Drafting Instruments. Signed:

THEO. G. ALTENADER, *President,*
Theo. Altenader & Sons,
Philadelphia, Pa.

COLLEGE NOTES

University of Illinois.—W. C. Huntington, Head of the Department of Civil Engineering, received the Alumni Norlin Recognition Medal for distinguished achievement from the University of Colorado in June, 1937. W. M. Wilson, Research Professor of Civil Engineering, was granted the Octave Chanute Medal from the Western Society of Engineers, on September 27, 1937, for his paper entitled: "The Present Status of Structural Welding." Professor Wilson received this honor in 1914, also, for a paper "The Analysis of Wind Stresses in the Frames of Office Buildings." C. W. Parmelee, Head of the Department of Ceramic Engineering, was elected to Honorary Membership in the German Ceramic Society at its meeting in Freiberg in September, 1937.

A. N. Talbot, Professor of Municipal and Sanitary Engineering, Emeritus, was awarded the John Fritz Medal from the American Society of Civil Engineers in January, 1937. He was awarded Life Membership in the Society at a meeting of the Central Illinois Section on December 16, 1937. Professor Talbot was graduated from the University of Illinois in 1881 and has been connected with the institution almost continuously since that time. For thirty-six years he was also in charge of the Department of Theoretical and Applied Mechanics. Of the 300 Bulletins published by the Engineering Experiment Station of the University of Illinois, Professor Talbot is author of 12 of them and senior author of 10 additional. Since its beginning in 1913, he has been Chairman of a Special Committee on Stresses in Railroad Track that has served jointly under the American Railway Engineering Association and the American Society of Civil Engineers. As a result of the researches in these organizations, the committee has published six voluminous reports embodying its studies and the findings of its investigations. Professor Talbot celebrated his eightieth birthday in October, at which time he received about 400 letters and telegrams of greetings from his friends throughout the country.

University of Maryland.—By operation of the new state retirement act, A. N. Johnson, Dean of the College of Engineering at the University of Maryland, has been retired. Professor S. S. Steinberg, Head of the Department of Civil Engineering who has been serving as Acting Dean, has been named Dean.

Massachusetts Institute of Technology.—About two years ago, work was begun at the Institute on a project to obtain intense mag-

netic fields in a form suitable for precise measurements. Instead of adopting the usual scheme of using large iron core electromagnets, or reverting to Kapitza's methods of passing surges of current through a solenoid for one one-hundredth of a second, it was decided to develop water-cooled coils carrying heavy current. This procedure made it possible to employ steady, homogeneous fields of great intensity covering amply large volumes for indefinite periods. The success of the enterprise depended entirely upon obtaining a suitable source of power. Through the courtesy of the Boston Edison Company, sufficient current was made available, together with space in one of their sub-stations for preliminary investigations. A small coil having about 160 turns was designed to carry 12,000 amperes, the heat generated by the 3000 kilowatts through the coil being disposed of by water flowing through it at the rate of 600 gallons per minute. The preliminary experiments indicated that this method was satisfactory, and it was decided, therefore, to install facilities for the operation of magnets of this type. Thus, it is now possible to carry on experiments involving both the new magnets and the other apparatus of the Institute.

A 1700-kilowatt generator producing a variable current up to 10,000 amperes is being installed next to the spectroscopy building, and three of the magnets are in process of construction. One will be used in the spectroscopy laboratory to give fields up to 100,000 gauss in a tube having an inside diameter of over one inch. A second will serve for low temperature work, producing fields of the order of 60,000 gauss. Finally, the original coil used at the Edison Company sub-station is being rebuilt to conform with the capacity of the new power plant. This third magnet will be utilized in a preliminary survey of the magnetic properties of certain types of alloys.

The present installation will make possible measurements that have not been previously attempted. It is exploratory work, and no one can safely predict what will be discovered.

A new housing for the Institute's large electrostatic high voltage generator is rapidly taking shape on Vassar St. The new arrangement of the generator structure is based on the results of a series of successful tests carried out at the M. I. T. field station at Round Hill, South Dartmouth, Mass.

The task of moving the generator from Round Hill to Cambridge involved problems in disassembly and reassembly because of the bulk and special nature of the spherical terminals and insulating columns. The spheres presented the greatest difficulty in actual transport, since they required 15 feet of road width and about 17 feet of height even though carried on a special low-slung trailer. In addition to the 8 tons of generator structure, the moving included 26 tons of apparatus and equipment.

Construction of the generator at Round Hill was started 5 years ago by Dr. L. C. Van Atta under the supervision of Professor R. J. Van de Graaff and with the collaboration of Dr. C. M. Van Atta and Mr. D. L. Northrup. The project was undertaken as a result of the successful performance of a laboratory model developed by Professor Van de Graaff. Voltages greater than 5 million were obtained in about one year. Since that time, attention has been devoted to the development of methods of precise voltage control and accurate voltage measurement, and of a vacuum tube to withstand the voltage and to serve for the acceleration of intense beams of electrons and positive ions.

With these preliminary problems satisfactorily solved, the generator has been moved to the Institute grounds in Cambridge in order that the nuclear research program to which it will be devoted may be most effectively pursued. In designing the new generator arrangement and housing the associated Nuclear Research Laboratory, the convenient and rapid conduct of nuclear research has been the first consideration. To this end, the generator terminals are placed in contact with electrical charging belts in one column and the discharge tube in the other. The driving motor for the belts and the bombarded target are then placed at ground potential and below ground level. This arrangement reduces the available voltage but enormously simplifies the use of detection equipment.

Preliminary bombardment work at Round Hill with a beam of electrons and a water-cooled, lead-lined target emphasized the difficulty of shielding the operators from the X-rays with the target above ground. In the present arrangement, the target is located 6 feet below ground level. The beam of most intense X-rays will be a narrow cone directed downwards to the bottom of a pit fifteen feet below ground level. Thus, shielding against X-rays should be relatively simple.

All generator controls and many spare pairs for electrical circuits are brought to several control panels in the underground rooms to facilitate operation at a distance. Throughout the new structure and in the alterations of the previously existing building every reasonable convenience for rapid experimental work has been included.

The derby-shaped steel building to house the generator will be of welded steel plate construction, smooth inside and stiffened outside only by a pair of welded I-beams. This building and all associated construction should be finished by the last of December. The generator will be in regular operation within a few months thereafter.

Michigan College of Mining and Technology.—Final enrollment figures for the fall term show a registration of 689 students,

an increase of not quite a score since the year's first report was mailed to the JOURNAL OF ENGINEERING EDUCATION. The present registration is exactly nine per cent higher than the previous record, set five years ago. Mechanical engineering leads with 134 students, followed closely by mining and by metallurgy, though if chemistry and chemical engineering are bracketed together the department teaching them would take second place. Freshmen total not quite one-third of the enrollment. There are 125 seniors. Students from Michigan account for 78.5 per cent; twenty other states and six foreign countries also contribute, Canada leading with 33 men.

The College will be host next November to the North-Midwest section of the S. P. E. E. This action, taken at the Milwaukee 1937 meeting, followed the election of officers during which Professor G. W. Swenson of Michigan Tech was chosen president and Professor N. H. Manderfield, secretary. Dr. James Fisher, dean of the Michigan Tech faculty, was appointed chairman of the mechanics division of the section.

Progress on the long-term campus improvement and beautification program was highlighted this fall by the appointment as consulting landscape architect of T. Glenn Phillips of Detroit, who has been retained by many municipalities, universities, and colleges to assist on similar projects. In the course of the fall term, also, the renovation and refurnishing of the faculty club room was completed.

Replacing Harold Walker, who resigned September 15 to become assistant professor of metallurgy at Washington State College, Gilbert W. Boyd, late in November, assumed his duties as assistant professor of metallurgy, teaching courses in metallography, alloyed steels and special ferrous alloys, and heat treatment. Professor Boyd received his B.S. and M.S. degrees from the University of Detroit and is completing his work for his Ph.D. degree at the University of Michigan. He has had eight years of teaching experience and has spent five years in industry. His professional affiliations include the American Chemical Society and the American Society for Metals.

Curriculum changes recently approved include the raising of graduation requirements from 6,600 credit hours to 7,000. This increase becomes effective next fall though it does not apply to present students. Changes in the mathematics department are headlined by expansion of the course in acoustics and by the introduction of a course in photography. Geodetic Surveying was transferred from the mathematics and physics to the civil engineering department but will continue to be taught by Dr. J. H. Service. Properties of Materials will be replaced by Chemical Properties of Materials, with a slight change in prerequisites. A required

course in advanced Technical Writing was also approved, to fill in the gap between the present junior-college course in that subject and the elective senior seminar in reports and theses.

The Ohio State University.—Peter Morrison, Assistant Professor of Machine Shop in the Department of Industrial Engineering, resigned last spring to accept the position of Works Manager of the Collins Radio Company, Cedar Rapids, Iowa. In his place Mr. Guy Cooper has been appointed Instructor. Mr. Cooper is a graduate of Ohio State University and has had wide experience with the Materials Laboratory of the Ohio State Highway Department and the railway industry.

Jack Small resigned last winter as Instructor in Engineering Drawing to accept a position with the City Engineer at Cincinnati, Ohio. On account of the large freshman enrollment, four Instructors have been appointed in this department. Paul E. Machovina received a degree from Ohio State in Mining Engineering in 1936 and has been employed in design at Timken Roller Bearing Company. Fairfax E. Watkins graduated in 1935 at Virginia Polytechnic Institute and comes here from Pittsburgh, Pennsylvania. Albert J. Philby graduated at Ohio State and has been teaching at Oak Harbor, Ohio. Hollie W. Shupe graduated in Architecture in 1936 at Ohio State and has been practicing in Columbus.

Seldom it is that an author relates the experiences and processes occurring during an extended research project. The results of research on foaming and priming of boiler water have been published in chemical and mechanical engineering journals, but now Professor C. W. Foulk of the Chemistry Department has written in popular style of his accidental discovery of the problem, together with the chronological account of progress during fourteen years. The story of scientific attacks on this puzzling problem is related in the December issue of the Engineering Experiment Station News.

A new course in Mechanics of Fluids has been started in the Mechanics Department. The work in Hydraulics which was a part of another course has been combined with the Fluids to form a three-credit hour course for one quarter. It is required in the Chemical, Civil, Mechanical, Metallurgical and Mine Engineering Curricula.

Villanova College.—The Mechanical Engineering Department has just received some new equipment for the Materials Testing Laboratory. The new equipment includes a 100,000 pound Tension-Compression Machine, Universal Impact Testing Machine, Brinell Hardness Tester, and a Static-Dynamic Balancing Machine.

SECTIONS AND BRANCHES

The Winter Meeting of the **Middle Atlantic Section** was held at Drexel Institute of Technology, Philadelphia, Pa., on Saturday, December 11, 1937.

Inspection trips started at 10:30 A.M., with parties visiting the United States Navy Yard including inspection of the Aircraft Factory and Ships; the R. C. A. Manufacturing Company, Camden, N. J., including a visit to the Television and Sound Pressure Measuring Laboratories; the Switchboard Factory of the General Electric Company, Philadelphia, Pa.; the E. G. Budd Manufacturing Company, Philadelphia, Pa., manufacturers of light trains and automobile bodies; and Esslinger's Brewery, Philadelphia.

After registration period the ladies, of which there were approximately forty, browsed in the Drexel Museum and at 11:00 A.M. listened to a lecture in the Art Gallery by Miss Dorothy Grafly, Curator of the Drexel Collections. At noon the ladies had a luncheon in the Ryder Club, and from 1:30 to 3:00 P.M. enjoyed a tour of the Sarah Van Rensselaer Dormitory, Practice House and Nursery School. At 3:00 P.M. they viewed a Fashion Show by the House Economics Department at the Dormitory.

A number of very favorable comments were heard from the visiting men concerning the innovation of a social hour from 4:00 to 6:00 P.M., which provided an excellent opportunity for all visitors to become better acquainted and to discuss problems of mutual engineering and educational interest. Also, from 4:00 to 6:00 P.M. the women had tea at the Dormitory and returned shortly before 6:00 P.M. to the Institute and gathered in the Women's Faculty Room.

The Technical Session was held at 2:00 P.M. in the Auditorium of the Institute. The meeting was opened by the Chairman, Dean R. L. Spencer, University of Delaware, and greetings were extended to the group by Dr. Parke R. Kolbe, President of Drexel Institute.

Professor F. L. Eidmann of Columbia University presented a paper on "The Young Engineering Graduate in Industry." This paper was a report of an investigation made by Professor Eidmann covering a period of approximately one year, during which time he visited many industrial organizations in this country and abroad, to determine the viewpoint of industry with regard to the desired training and other qualifications which they desired in

young graduates in their employ. The major portion of Professor Eidmann's paper was devoted to direct quotations of executors and administrators of a large group of industries. Professor Eidmann then presented his conclusions.

The paper was discussed by W. P. Argyle of the Sinclair Refining Company; H. W. Dean of the Bell Telephone Company of Pennsylvania; J. M. McIlvain, Atlantic Refining Company; J. A. Hopwood, Philadelphia Electric Company; and George B. Thomas and his Associate, R. A. Deller, Bell Telephone Laboratories of New York.

In general, expressions of opinion by both Professor Eidmann and those who contributed to the discussions seem to emphasize the fact that our engineering graduates are technically well prepared for their work, but require a year or two to reach an attitude of practical development and interest in their work. Some criticism was voiced that the young engineering graduate was adverse to tackling dirty work and coming up from the lowest rung of the ladder. There seemed to be a desire on his part to advance more rapidly than his technical training and practice would warrant. Considerable emphasis was placed by all the speakers on the continued lack of ability on the part of technically trained college men to express themselves properly both in writing and in speech. Professor Eidmann pointed out that the engineering schools of the country were familiar with all of the educational aspects which were under criticism and that means were being taken to correct them in practically all technical institutions.

At 6:00 P.M. dinner was served in the Men's Lounge, Dean Robert C. Disque of Drexel Institute acted as Toastmaster. Dr. Kolbe again welcomed the entire group to Drexel Institute. A special musical program by the Glee Club of the Engineers Club of Philadelphia was given prior to the dinner.

Professor C. D. Fawcett, as Secretary, announced that there was a total attendance of 245, including 205 men and 40 women. The dinner was enjoyed by 176.

The Committee on "Time and Place" consisting of Professors R. C. H. Heck, Chairman, W. I. Slichter and H. M. Fry, announced that the next Mid-winter 1938 Meeting would be held at New York University, New York City. The Committee also reminded the group that the Spring Meeting 1938 would be held at Lafayette College, Easton, Pa.

The Nominating Committee consisting of Professors Thorndike Saville, Chairman, T. D. Mylrea and Morland King, presented the names of the following members for officers for the year 1938:

President—Dean P. H. Daggett, Rutgers University, New Brunswick, N. J.

Vice-President—Professor Mortimer F. Sayre, Union College, Schenectady, N. Y.

Secretary-Treasurer—Professor C. D. Fawcett, University of Pennsylvania, Philadelphia, Pa.

Following the dinner Professor A. K. Van Tine of the Department of Psychology of the Drexel Institute, gave an historical sketch of crime detection by the use of "lie detectors," and followed this talk with a demonstration of an electrical apparatus developed for this purpose. His demonstration included some five or six tests, practically all of which presented conclusive proof that the machine was capable of detecting liars.

C. D. FAWCETT,
Secretary-Treasurer.

The **Pennsylvania State College Branch** of the S. P. E. E. elected the following officers for the year 1937–1938:

President:	Professor L. A. Doggett
Vice President:	Professor C. E. Bullinger
Secretary:	Professor A. P. Powell

Dean H. P. Hammond spoke on the 45th Annual Meeting of the Society held at Cambridge last June and gave us a President's viewpoint. In so doing he anticipated for us the Penn State meeting of the Society to be held in 1939, especially in regard to the magnitude of the meeting!

ALBERT P. POWELL, *Secretary.*

CORRECTIONS

NOVEMBER JOURNAL.—Mechanics Division: Executive Committee, H. J. Gilkey, Chairman, F. T. Mavis, W. J. Cox, T. J. Dolan, S. B. Folk, W. B. Johns and C. T. Olmsted.

DECEMBER JOURNAL.—The enrollment at Notre Dame was added on page 344 but not included in the Total in United States on page 347. This total should be Freshmen, 27,713; Sophomores, 20,646; Juniors, 15,618; Seniors, 11,887; Fifth-Year, 625; Specials, 353; Evening Students, 7,341; Others, 575; Total, 84,547; First degrees conferred in 1936–37, 8,245.

Page 340 should be headed 5 schools in Canada instead of 126 schools in United States.

Page 327. The title of Professor Hardy Cross' paper was "Soiled Mechanics" instead of "Soil Mechanics."

EDITOR

G-E *Campus News*

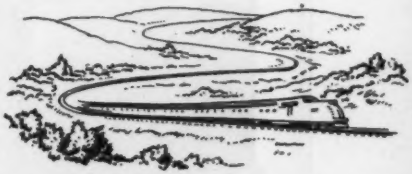
NETWORK ANALYZER

WITH the aim of aiding public utilities in laying out power systems, R. N. Slinger, Oregon State '26, R. G. Lorraine, U. of Colorado '27, and H. P. Kuehni, Eidgen Technische Hochschule '20, Zurich, Switzerland, Union '29, spent more than a year in designing and constructing an alternating-current network analyzer. The apparatus is so arranged that any distribution circuit in the country may be stimulated merely by plugging various impedance units and power sources from the plugging cabinets and reading the results on the master instrument panel. The a-c analyzer, a miniature power system, provides General Electric engineers with an advanced tool for system analysis and is made available to utility operating companies for their individual problems. Speed and accuracy of calculations are the two main advantages of the analyzer, and any experienced operator can, in two or three days, solve network problems which would take months to work out using other methods.

The network analyzer, as well as many other electric and mechanical developments, have been designed by former student engineers now in the electrical industry.

RUBBER RAILROAD RAILS

NO, the railroad companies have not started to use rubber rails, but the new welded steel rails that are a mile in length have many of the characteristics which rubber rails probably would have. Developed after research and experimental work by the Delaware and Hudson Railroad, Sperry Products Company, and General Electric Company, the welding which makes possible these mile-long rails, introduces flash butt welding of the preheated ends of regular-length rails to form one long continuous rail.



When these rails are loaded on flatcars, they bend easily around the sharpest curves as they are carried to the spot where they are to be laid. In addition to their flexibility, the rails are remarkably quiet. No longer will there be the continual bump and clatter of wheels over worn and gaping rail joints to disturb sleeping passengers. To reduce the noise even more, the rails are laid so that there will be no two parallel joints.

The flexibility and smoothness of the new rails reduce the wear and tear on the rolling stock, so that the initial expenditure for the rails will be compensated by the saving on maintenance.

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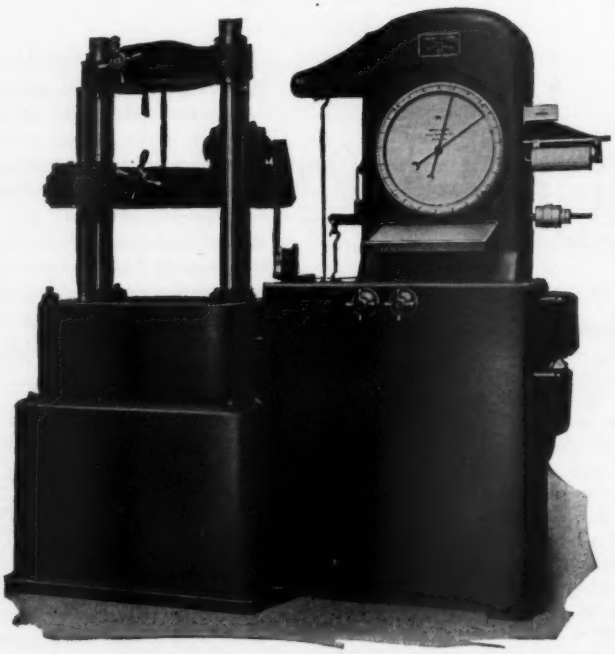

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